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(54) Title: APPARATUS AND PROCESS FOR SEPARATING A SOUR GAS INTO SWEETENED GAS AND SOUR LIQUID

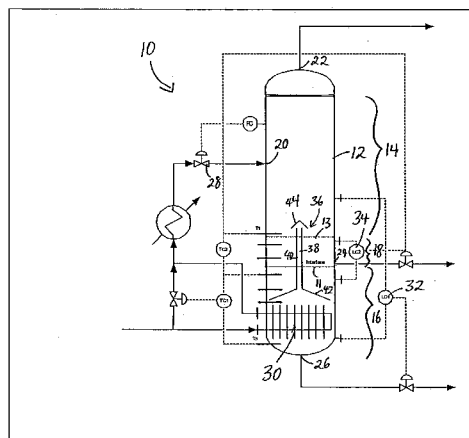


Figure 1

(57) Abstract: An apparatus and process for separating a sour gas into sweetened gas and sour liquid is provided. The apparatus comprises a separator vessel having a vapour space and a sour liquid collection zone; a means for introducing the sour gas stream into the vapour space, the vapour space being arranged to operate under conditions whereby introducing the sour gas stream into the vapour space produces a mixture of sour liquid and/or solids, hydrocarbon vapour and, optionally, hydrocarbon liquid, the sour liquid and/or solids and the hydrocarbon liquid, if present, separating under gravity and density to the sour liquid collection zone, thereby producing sweetened gas in the vapour space; a heating means in the sour liquid collection zone for melting sour solids that collect in the sour liquid collection zone into sour liquid; an outlet for withdrawing sweetened gas from the vapour space; an outlet for withdrawing sour liquid from the sour liquid collection zone; and means for controlling a level of the sour liquid in the separator vessel.



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APPARATUS AND PROCESS FOR SEPARATING A SOUR GAS INTO SWEETENED
GAS AND SOUR LIQUID

Field

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The present invention relates to an apparatus and process for separating a sour gas into sweetened gas and sour liquid.

Background

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In a two-phase vapour-liquid separator, liquid level control is relatively easy to manage. The liquid level within the separator can be allowed to fluctuate quite widely without compromising vapour-liquid separation because controlling the pressure conditions within the vessel will maintain steady state equilibrium as the liquid level within the vessel changes.

Liquid level control is much more difficult in a multiphase process separator in which vapour, one or more liquids, and solids are formed and co-exist. The management of solids is particularly problematic. For example, solids may form and accumulate on the walls of the separator. Periodic accumulation of solids in the vapour space of the separator followed by sudden bulk entry of solids into the liquid phase will have the effect of disrupting the liquid level within the separator. Further, when the temperature of the liquid phase lies above the melting point of the solids collected within the liquid phase, the temperature of the liquid phase

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will also change due to the release of latent heat from the melting solids.

In the cryogenic separation of carbon dioxide from natural
5 gas streams, the natural gas stream is cooled to temperatures
at which carbon dioxide (and other sour contaminants and
freezable hydrocarbon components) condense and/or solidify to
produce a slurry of solid sour contaminants in a hydrocarbon
liquid and a sweetened vapour stream. The solid contaminants
10 may be preferably melted before removing the contaminant
stream from the separator as a liquid. Melting of such
solids is generally facilitated by introducing a heater into
the portion of the separator where the slurry collects.
Therefore, the liquid phase in the separator may be at a
15 higher temperature than the vapour phase. The ability to
control temperature equilibrium conditions within such a
separator is much more complex than in a two-phase vapour-
liquid separator. The inventors have realised after
substantial field testing that the ability to control the
20 liquid level is inter-related to heater control within the
separator and is therefore very important in this regard.

This becomes additionally important where a two phase liquid-
liquid interface between a denser, warmer CO₂-rich stream and
25 a lighter, colder hydrocarbon-rich liquid stream is
established within the separator. The temperature conditions
under which solid species melt may also cause vapourisation
of the hydrocarbon liquids and liquid CO₂.

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Several patents discuss the separation of carbon dioxide from natural gas streams through the formation of solid carbon dioxide followed by controlled melting of the solids. Engdahl et al. (US Patent No. 5,819,555) in particular
5 discusses establishing a vertical temperature gradient in a liquid collected at the bottom of a separation vessel, and consequent formation of liquid that is more carbon dioxide rich towards the bottom of the vessel and more hydrocarbon rich towards the top of the liquid. While this patent
10 describes the removal of two liquid streams, one from the bottom of the vessel and one from the side, it does not describe how to establish and maintain a separation vessel in which two miscible liquid phases of different densities and temperature, such as liquid carbon dioxide and liquid
15 hydrocarbon, form and co-exist. Nor does it describe how to maintain a stable interface between the two phases which is continually disturbed by solid particles of carbon dioxide falling through the upper liquid hydrocarbon layer. US 5,819,555 also fails to recognize the importance of
20 continuous and steady melting of solid CO₂ in order to maintain a stable operation of the separation process. The above patent also lacks essential details of the interaction between liquid level and liquid temperature control with regard to maintaining a stable process.

25

In these processes the gas is cooled to a point at which solid sour species, typically carbon dioxide, and liquid hydrocarbons form. These are separated from the gas in a separating vessel and the solid sour species are melted into
30 the liquid phase to enable withdrawal.

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Under certain operating conditions it is possible to form two distinct liquid phases in the separating vessel. Whilst it has been shown, with extensive pilot plant trials, to be operationally advantageous to operate with two liquid phases, the interface between the liquid phases is inherently unstable and difficult to control, particularly when the upper liquid layer is not withdrawn from the vessel. Several hydrocarbon species, ethane in particular, are condensed at temperatures encountered in the vapour phase, but are re-vapourised at temperatures encountered in the liquid phase. This can result in re-boiling in the liquid phase causing re-vapourisation of carbon dioxide back into the vapour phase, leading to a higher vapour temperature. This in turn leads to higher energy consumption in order to maintain the vapour temperature and can lead to a higher than desired concentration of carbon dioxide in the vapour stream, and consequently poorer separation between the vapour, liquid and solid phases. All of the above factors also increase the convection and conduction forces and currents in the liquid layers, making it harder to form two separate layers.

Additionally, once the separate layers are formed then any solids formed in the vapour space will fall through the colder upper layer before they are melted in the lower layer, making control of the interface difficult, due to the thermal perturbations in the vicinity of the interface.

The present invention seeks to overcome at least some of the aforementioned disadvantages.

Summary

5 In its broadest aspect, the invention provides an apparatus and process for separating a sour gas into sweetened gas and sour liquids. In particular, the apparatus is adapted to control a level of sour liquid in the separator vessel while maintaining a steady melting and removal of the solid species.

10

Accordingly, in a first aspect of the present invention there is provided an apparatus for separating a sour gas stream into sweetened gas and sour liquid comprising:

15 a separator vessel having a vapour space and a sour liquid collection zone;

a means for introducing the sour gas stream into the vapour space, the vapour space being arranged to operate under conditions whereby introducing the sour gas stream into the vapour space produces a mixture of sour liquid and/or solids, hydrocarbon vapour and, optionally, hydrocarbon liquid, the
20 sour liquid and/or solids and the hydrocarbon liquid, if present, separating under gravity and density to the sour liquid collection zone, thereby producing sweetened gas in the vapour space;

25 a heating means in the sour liquid collection zone for melting sour solids that collect in the sour liquid collection zone into sour liquid;
an outlet for withdrawing sweetened gas from the vapour space;

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an outlet for withdrawing sour liquid from the sour liquid collection zone;
and means for controlling a level of the sour liquid in the separator vessel.

5

In one embodiment of the invention, said means controls the sour liquid at a desired level in the separator vessel.

It will be appreciated that the sour liquid in the sour liquid collection zone may be maintained at a higher temperature than the vapour space to melt solids which collect in the sour liquid collection zone. The temperature of the sour liquid may be therefore largely controlled by controlling operation of the heater. However, due to the lag times generally experienced in temperature control (and the inherent temperature hysteresis in the liquid phase), and the accumulation of solids in the sour liquid collection zone, the inventors have realized that maintaining temperature control in the sour liquid collection zone is also facilitated by maintaining stable control of the liquid level in the apparatus.

In one embodiment of the invention, means for controlling the liquid level in the separator vessel comprises a non-stick surface provided on interior wall(s) of the separator vessel. The non-stick surface may extend continuously on the entire interior wall(s) of the separator vessel or may extend substantially over the interior wall(s) of the separator vessel disposed in the vapour space therein. Such non-stick surfaces may be provided by coating or lining a surface of

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the separator vessel with a material capable of preventing solid accumulation on the separator vessel walls. An illustrative example of such suitable materials includes, but is not limited to, TeflonTM. In this way, the non-stick surface prevents solid accumulation on the separator vessel walls, thereby preventing sudden increases in liquid volume and liquid level, and temperature disruption in the liquid phase. The non-stick surface therefore facilitates a continuous and substantially constant supply of solids into the sour liquid collection zone.

In another embodiment, the means for controlling the liquid level in the separator vessel comprises a liquid level control valve assembly in fluid communication with the outlet in the sour liquid collection zone.

In a preferred embodiment, the liquid level control valve assembly maintains the liquid level at the desired level in the separator vessel.

Depending on the composition of the sour gas stream, under certain cryogenic operating conditions a two phase liquid-liquid interface between a denser, warmer CO₂-rich stream and a lighter, colder hydrocarbon-rich liquid stream may be established within a separator vessel, and it is important to not only control the liquid level within the separator vessel but to maintain a substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel.

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Accordingly, in a second aspect of the present invention there is provided an apparatus for separating a sour gas stream into sweetened gas, liquid hydrocarbon, and sour liquid comprising:

- 5 a separator vessel having an upper vapour space, a lower sour liquid collection zone, and an upper hydrocarbon liquid collection zone disposed between the upper vapour space and the lower sour liquid collection zone;
- a means for introducing the sour gas stream into the upper
- 10 vapour space, the upper vapour space being arranged to operate under conditions whereby introducing the sour gas stream into the upper vapour space produces a mixture of sour liquid and/or solids, hydrocarbon vapour and hydrocarbon liquid, the sour liquid and/or solids and the hydrocarbon
- 15 liquid separating under gravity and density to the lower sour liquid collection zone and the upper hydrocarbon liquid collection zone, respectively, thereby producing sweetened gas in the upper vapour space;
- a heating means in the lower sour liquid collection zone for
- 20 melting sour solids that collect in the lower sour liquid collection zone into sour liquid;
- an outlet for withdrawing sweetened gas from the upper vapour space;
- an outlet for withdrawing hydrocarbon liquid from the upper
- 25 hydrocarbon liquid collection zone;
- an outlet for withdrawing sour liquid from the lower sour liquid collection zone;
- and means for maintaining a substantially stable interface between the hydrocarbon liquid and the sour liquid in the
- 30 separator vessel.

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In one embodiment of the invention, said means maintains the substantially stable interface between the hydrocarbon liquid and the sour liquid at a desired level in the separator
5 vessel.

The term "substantially stable interface" as used herein refers to a substantially continuous horizontal boundary between an upper hydrocarbon rich liquid phase and a lower
10 sour liquid rich phase which are distinguished by their density and temperature. It will be appreciated that the sour liquid and hydrocarbon liquid have a degree of mutual solubility and therefore the horizontal boundary between the upper and lower liquid phases will comprise a transition
15 region whose thickness will vary according to thermodynamic and kinetic parameters known to those skilled in the art, as well as temperature and pressure conditions in the separator vessel.

20 In one embodiment of the invention, the means for introducing the sour gas stream into the upper vapour space may comprise an inlet in the upper vapour space of the separation vessel. In a preferred form of the invention, a gas expansion device defines the inlet of the upper vapour space. Suitable
25 examples of such gas expansion devices include, but are not limited to, Joule-Thomson valves, venturi devices, turbo expanders, and so forth.

In another embodiment, the means for introducing the sour gas
30 stream into the upper vapour space may further comprise means

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to introduce the sour gas stream into the upper vapour space with a spiral flow to aid separation of the mixture of sour liquid and/or solids, methane vapour and hydrocarbon liquid produced in the upper vapour space. Alternatively, the means
5 may comprise other suitable separation means.

In one embodiment of the invention, the heating means is a heater, in particular an immersion heater.

10 In one embodiment, the means for maintaining a substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel comprises a first level control valve assembly in fluid communication with the outlet in the lower sour liquid collection zone and a second level
15 control valve assembly in fluid communication with the outlet in the upper hydrocarbon liquid collection zone.

In a preferred embodiment, the first and second level control assemblies maintain the substantially stable interface
20 between the hydrocarbon liquid and the sour liquid at the desired level in the separator vessel.

In a further embodiment, the first and second level control assemblies also maintain a substantially stable interface
25 between the upper vapour space and the upper hydrocarbon liquid phase. In a preferred embodiment, the first and second level control assemblies maintain the substantially stable interface between the upper vapour space and the upper hydrocarbon liquid phase at a desired level in the separator
30 vessel.

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It will be appreciated that the apparatus of the present invention is operated under conditions where solid particles of sour species form in the vapour space and migrate
5 downwardly through the upper hydrocarbon liquid phase before reaching the lower sour species liquid phase. The movement of solids through the liquid phases makes it difficult to accurately determine the location of the liquid-liquid
10 interface in the vessel because the determination of the location of the interface in the vessel is typically conducted by sensing the density of each of the phases (for example by using ultrasonic measurements) and the falling solids interfere with the measurements and/or provide false readings. The movement of solids through the liquid phases
15 also disturbs the interface therebetween.

In one form of the invention, the first and second level control valve assemblies may be operatively controlled in response to signals received from one or more probes and/or
20 sensors disposed in the lower sour liquid collection zone and/or the upper hydrocarbon liquid collection zone. The probes and/or sensors are arranged in use to measure one or more of physical parameters within the respective liquid phases which remain relatively unaffected by falling solids
25 in the liquid phases. Suitable examples of such physical parameters include, but are not limited to, differential temperature, RF capacitance, and so forth, as will be known to persons skilled in the art.

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In a further form, the control valve assemblies may also be operatively controlled in response to signals from sensors disposed in the upper vapour space of the vessel.

5 It will be appreciated that some hydrocarbon liquid may become entrained in the sour liquid collected in the lower sour liquid collection zone. As the temperature of the sour liquid in the sour liquid collection zone, and particularly proximal to the heating means, is likely to be greater than
10 the boiling point of the hydrocarbon liquid, the entrained hydrocarbon liquid may be re-vapourised in the sour liquid collection zone and/or proximal to the heating means.

Consequently, hydrocarbon vapour bubbles may be generated and
15 rise through the sour liquid. If allowed to rise freely these vapour bubbles will disturb the interface between the sour liquid and hydrocarbon liquid phases, cause undesired mixing and turbulence between the sour liquid and hydrocarbon liquid phases, and interfere with the settling of solids
20 through the upper hydrocarbon liquid phase. Further, bubbling might also cause change in physical properties, such as density, causing the level transmitters to indicate unsteady readings, which in turn might lead to an unsteady process operation.

25

Accordingly, in a further embodiment of the present invention, the means for maintaining a substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel further comprises means for directing
30 vapour generated in the sour liquid collection zone to the

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upper vapour space. The directing means is configured to minimise disturbance of the vapour-liquid interface and/or liquid-liquid interace.

5 In one embodiment the directing means comprises a riser assembly to facilitate fluid communication between the lower sour liquid collection zone and the upper vapour space. In one form the riser assembly comprises a vertical component extending upwardly from a lower conical component, the lower
10 conical component being disposed in the sour liquid collection zone and the vertical component extending through the hydrocarbon liquid collection zone and terminating in the upper vapour space of the separator vessel. Preferably, the lower conical component is disposed above and proximal to the
15 heating means. Hydrocarbon vapour generated from entrained hydrocarbons in the sour liquid collection zone enters the conical component and passes upwardly through the conical component and the vertical component and exits the vertical component in the upper vapour space without encountering the
20 upper liquid layer.

In one form, the riser assembly may be formed from material having low thermal conductivity.

25 In another form, the riser assembly is provided with non-stick surfaces and downward sloping surfaces to prevent falling solids from accumulating thereon.

In another form the vertical component may be configured to
30 prevent sour solids from entering from the top. Preferably

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the vertical component is provided with a cap having downwardly inclined surfaces. The cap may be configured to expel hydrocarbon vapour substantially laterally into the upper vapour space.

5

In a still further embodiment of the invention, the separator vessel is provided with an inlet disposed in the lower sour liquid collection zone, wherein the inlet is configured to introduce sour liquid into the lower sour liquid collection
10 zone. This particular feature may be useful to facilitate establishment of two distinct liquid layers in the separator vessel, particularly during start up operations.

In a third aspect of the invention there is provided a
15 process for separating a sour gas stream into sweetened gas, liquid hydrocarbon, and sour liquid comprising the steps of: introducing the sour gas stream into an upper vapour space of a separator vessel operated under conditions to produce a mixture of sour liquid and/or solids, hydrocarbon vapour and
20 hydrocarbon liquid in the upper vapour space;
allowing the sour liquids and/or solids and the hydrocarbon liquid to separate under gravity and density to a lower sour liquid collection zone and an upper hydrocarbon liquid collection zone provided in the separator vessel,
25 respectively, thereby producing a sweetened gas in the upper vapour space;
melting sour solids that collect in the lower sour liquid collection zone into sour liquid;
withdrawing sweetened gas from the upper vapour space;

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withdrawing hydrocarbon liquid from the upper hydrocarbon liquid collection zone; and
withdrawing sour liquid from the lower sour liquid collection zone;

- 5 wherein the step of withdrawing the hydrocarbon liquid and/or the step of withdrawing the sour liquid is performed in a manner to maintain a substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel.

10

In a preferred embodiment, the step of withdrawing the sour liquid is performed in a manner to maintain the substantially stable interface between the hydrocarbon liquid and the sour liquid at a desired level in the separator vessel.

15

In a further embodiment, the step of withdrawing the sour liquid is performed in a manner to maintain a substantially stable interface between the upper vapour space and the upper hydrocarbon liquid phase. In a preferred embodiment, the
20 step of withdrawing the sour liquid is performed in a manner to maintain the substantially stable interface between the upper vapour space and the upper hydrocarbon liquid phase at a desired level in the separator vessel.

- 25 In one embodiment, the process comprises heating the sour solids to a temperature at or just above the melting point of the sour solids.

In one embodiment of the invention the step of withdrawing
30 the hydrocarbon liquid and/or the step of withdrawing the

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sour liquid comprises controllably withdrawing the hydrocarbon liquid and/or the sour liquid with respective first and second level control valve assemblies in response to signals received from one or more probes and/or sensors
5 disposed in the lower sour liquid collection zone and/or the upper hydrocarbon liquid collection zone and/or the upper vapour space of the separator vessel for determining the interface.

10 In one form of the invention, the separator vessel is operated under a set of temperature and pressure conditions at which the sour species solidifies and/or a liquid condensate of sour species forms. It will be appreciated that the set of temperature and pressure conditions will vary
15 in accordance with the desired composition of the product gas stream. In one embodiment of the invention, the sour gas stream is cooled prior to introduction to the upper vapour space of the separator vessel to a temperature at or just below the temperature at which the sour species solidifies
20 and/or condenses.

In one form of the invention, the step of cooling the sour gas stream comprises cooling and expanding the sour gas stream in one or more expansion steps. Alternatively, the
25 step of cooling the gas stream comprises effecting a direct heat exchange with a cooling stream.

It will be appreciated that the sour gas stream may be pre-cooled to a temperature just above the temperature at which

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the sour species solidifies and/or condenses prior to introducing the sour gas stream into the separator vessel.

Brief Description of the Figure

5

A preferred embodiment of the present invention will now be described, by way of example only, with reference to the accompanying figure, in which:

Figure 1 shows a schematic diagram of an apparatus for
10 separating a sour gas stream into sweetened gas and sour liquid in accordance with one embodiment of the present invention;

Figure 2 shows a schematic diagram of an alternative embodiment of the apparatus shown in Figure 1; and

15 Figure 3 shows a schematic diagram of an apparatus for separating a sour gas stream into sweetened gas and sour liquid in accordance with a further embodiment of the present invention.

20 Description of a Preferred Embodiment

Referring to Figure 1-3, where like reference numerals refer to like parts throughout, in accordance with various aspects of the present invention, there is shown an apparatus 10 for
25 separating a sour gas stream into sweetened gas, liquid hydrocarbon, and sour liquid.

In Figure 1, the apparatus 10 includes a separator vessel 12 having an upper vapour space 14, a lower sour liquid
30 collection zone 16, and an upper hydrocarbon liquid

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collection zone 18 disposed between the upper vapour space 14 and the lower sour liquid collection zone 16.

It will be appreciated that a reference to a hydrocarbon liquid may encompass a "rich hydrocarbon liquid" comprising a mixture of one or more condensable hydrocarbons and one or more sour or other components. Similarly, a reference to a sour liquid may encompass a rich sour liquid comprising a mixture of one or more sour contaminants and one or more hydrocarbons. The wt% of hydrocarbons is greater than the sour components in a rich hydrocarbon liquid, and conversely the wt% of sour components is greater than the hydrocarbon components in a rich sour liquid.

The interior walls of the separator vessel 12 are provided with a non-stick surface. The non-stick surface may extend continuously on the entire interior wall(s) of the separator vessel 12 or may extend substantially over the interior wall(s) of the separator vessel 12 disposed in the vapour space 14 therein. Such non-stick surfaces may be provided by coating or lining a surface of the separator vessel 12 with a material capable of preventing solids accumulation on the separator vessel walls. An illustrative example of such suitable materials includes, but is not limited to, TeflonTM. In this way, the non-stick surface prevents solids accumulation on the separator vessel walls, thereby preventing sudden increases in liquid volume and a consequent rise in liquid level, and temperature disruption in the liquid phase of the vessel 12. The non-stick surface

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therefore facilitates a continuous and substantially constant supply of solids into the sour liquid collection zone.

The separator vessel 12 is provided with an inlet 20 for
5 introducing a sour gas into the upper vapour space 14, an
outlet 22 for withdrawing sweetened gas from the upper vapour
space 14, an outlet 24 for withdrawing hydrocarbon liquid
from the upper hydrocarbon liquid collection zone 18, and an
outlet 26 for withdrawing sour liquid from the lower sour
10 liquid collection zone 16.

The upper vapour space 14 of the separator vessel 12 is
arranged to operate under conditions whereby introducing the
sour gas stream into the upper vapour space 14 produces a
15 mixture of sour liquid and/or solids, methane vapour and
hydrocarbon liquid. Typically, the sour gas stream is cooled
on introduction to the upper vapour space 14 of the separator
vessel 12 to a temperature at or just below the temperature
at which the sour species in the sour gas stream solidifies
20 and/or condenses. It will be appreciated that the operating
temperature and pressure of the separator vessel 12 will vary
in accordance with the desired composition of the sweetened
gas stream.

25 To assist in cooling the sour gas stream in the upper vapour
space 14 of the separator vessel 12, the inlet 20 may be
defined by a gas expansion device 28. In the embodiment
shown in Figure 1, the gas expansion device is a Joule-
Thomson valve, but alternative suitable examples of gas

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expansion devices 28 include venturi devices, turbo expanders, and so forth.

Although not shown in the present embodiment, the inlet 20
5 may also include an inlet device to assist or enhance separation of liquid and/or solid sour species and liquid hydrocarbon from the mixture formed in the upper vapour space 14. Some inlet devices are designed to coalesce droplets or agglomerate solid particles. Other inlet devices are
10 configured to introduce the sour gas stream into the upper vapour space 14 with a swirl to aid separation of the mixture of sour liquid and/or solids, methane vapour and hydrocarbon liquid produced in the upper vapour space 14.

15 The separator vessel 12 is also provided with a heating means 30 disposed in the lower sour liquid collection zone 16 for melting sour solids that collect in the lower sour liquid collection zone 16 into sour liquid. With reference to Figure 1, the heating means 30 is a heater, such as, for example, a
20 heat exchanger or an immersion heater.

The apparatus 10 also includes a first level control valve assembly 32 in fluid communication with the outlet 26 in the lower sour liquid collection zone 16, and a second level
25 control valve assembly 34 in fluid communication with the outlet 24 in the upper hydrocarbon liquid collection zone 18. The first level control valve assembly 32 determines the withdrawal of sour liquid from the lower sour liquid collection zone 16 and the second level control valve

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assembly 34 determines the withdrawal of hydrocarbon liquid from the upper hydrocarbon liquid collection zone 18.

The first and second level control valve assemblies 32, 34
5 are operatively controlled in response to signals received from one or more probes and/or sensors disposed in the lower sour liquid collection zone 16 and/or the upper hydrocarbon liquid collection zone 18 and/or the upper vapour space 14 of the separator vessel 12, as shown in Figure 1. The probes
10 and/or sensors are arranged in use to measure one or more of physical parameters within the separator vessel selected from the group comprising differential temperature, RF capacitance, differential pressure, hydrostatic pressure, and so forth, as will be known to persons skilled in the art.
15 The probes and sensors illustrated in Figure 1 are illustrative of differential temperature changes between the lower sour liquid collection zone 16, the upper hydrocarbon liquid collection zone 18, and the upper vapour space 14 of the separator vessel 12, respectively.

20

The apparatus 10 also includes a means 36 for directing vapour generated in the sour liquid collection zone 16 to the upper vapour space 14. The means 36 is configured to minimise disturbance of the interface 11 between the sour
25 liquid and hydrocarbon liquid.

In the embodiment shown in Figure 1, the means 36 comprises a riser assembly 38 having a vertical component 40 extending upwardly from a lower conical component 42, the lower conical
30 component 42 being disposed in the sour liquid collection

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zone 16 and the vertical component 40 extending through the hydrocarbon liquid collection zone 18 and terminating in the upper vapour space 14 of the separator vessel 12. Hydrocarbon vapour generated in the sour liquid collection
5 zone 16 enters the lower conical component 42 and passes upwardly through the lower conical component 42 and the vertical component 40 and exits the vertical component 40 in the upper vapour space 14.

10 Preferably, the riser assembly 38 may be formed from material having low thermal conductivity. Additionally or alternatively, the riser assembly 30 is provided with non-stick surfaces and downward sloping surfaces to prevent falling solids from accumulating thereon.

15

In another form the vertical component 40 may be configured to prevent sour solids from entering from the top. Preferably the vertical component 40 is provided with a cap
20 44 having downwardly inclined surfaces. The cap may be configured to expel hydrocarbon vapour substantially laterally into the upper vapour space. The cap may also be formed from material having low thermal conductivity and/or be provided with non-stick surfaces for reasons as described above.

25

The separator vessel 12 may be also provided with an inlet (not shown) disposed in the lower sour liquid collection zone 16, wherein the inlet is configured to introduce sour liquid into the lower sour liquid collection zone 16. This
30 particular feature may be useful to facilitate establishment

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of two distinct liquid layers in the separator vessel 12, particularly during start up operations.

The apparatus 10' shown in Figure 2 includes all the features described with reference to Figure 1. Additionally, the separator vessel 12 is provided with a weir 46 disposed in the lower sour liquid collection zone 16. Said weir 46 is constructed of a low thermal conductivity material to minimize heat transfer from the sour liquid to the collected hydrocarbon liquid.

The apparatus 10" shown in Figure 3 operates on a similar basis to the apparatuses described with reference to Figures 1 and 2 except that it is configured to separate a sweetened hydrocarbon gas and a sour liquid. A liquid level 15 of the sour liquid is controlled by the first level control valve assembly 32 in fluid communication with the outlet 26 in the lower sour liquid collection zone 16.

Operation of the apparatus of the present invention will now be described with reference to the Figures.

Throughout the description reference is made to a natural gas stream as an example of the sour gas stream that may be treated in the process according to the present invention. It will be appreciated, however, that the sour gas stream may be any stream of gas that comprises hydrocarbons and sour species. Illustrative examples of such sour gas streams include, but are not limited to, natural gas, coal seam gas, associated gas, landfill gas, and biogas. The composition of

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the sour gas stream may vary significantly but the sour gas stream will generally contain methane, ethane, higher hydrocarbons (C3+), water, and sour species. The term "sour species" means any one or more of carbon dioxide, hydrogen sulphide, carbon disulfide, carbonyl sulphide, mercaptans (R-SH, where R is an alkyl group having one to 20 carbon atoms), sulphur dioxide, aromatic sulphur-containing compounds, and aromatic hydrocarbons such as benzene, toluene, xylene, naphthalenes, and so forth.

10

It will be appreciated that the sour gas stream that is used in the present process has been dehydrated. Generally the sour gas stream has a water content of less than 50 ppm, and preferably less than 7 ppm for pipeline specification gas, and a water content of less than 1 ppm for LNG specification gas. Any suitable process for dehydrating the sour gas stream can be used. An example of a suitable dehydration process includes the adsorption of water from the gas stream with molecular sieves or silica gel. Alternatively, dehydration by adsorption using glycol or methane may be possible, or other suitable dehydration processes known in the art.

15

The sour gas stream is cooled to a temperature below the temperature at which (hydrocarbon) liquids form and/or just above the temperature at which sour solids form prior to introducing the sour gas stream into the separator vessel 12 through valve 28. The sour gas stream may be cooled by indirect heat exchange with a cooling stream or a refrigerant stream in a heat exchanger or cold box. Alternatively, the sour gas stream may be cooled by expansion in one or more

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- 25 -

conventional gas expansion devices. Generally, the sour gas stream is cooled to a temperature in a range of about -65 °C - -70 °C.

5 The cooled sour gas stream is further cooled to a temperature at or just below the temperature at which sour solids form by expanding the cooled sour gas stream through the Joule-Thomson valve 28 that, together with line 15, defines the inlet 20 of the separator vessel 12. Other
10 suitable expansion means such as a turbo expander to further cool the stream as it enters the separator vessel 12 may be used, including using a turbo expander in sequential combination with the Joule-Thomson valve.

15 The process of expanding the sour gas stream upon introduction to the upper vapour space 14 of the separator vessel 12 is arranged to afford temperature and pressure conditions within the upper vapour space 14 of the separator
20 vessel 12 at which the sour species contained in the sour gas stream solidify and/or liquefy. The process of expansion typically cools the gas stream entering the upper vapour space 14 of the separator vessel 12 at inlet 20 to a temperature in a range of about -80 to -95 °C under a pressure within a pressure range of 15 to 20 bar.

25 Upon cooling the sour gas stream, as described above, liquid hydrocarbons, NGLs, also form under the temperature and pressure conditions in the upper vapour space 14 of the separator vessel 12 together with methane vapour.

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The sour liquid and/or solids and the hydrocarbon liquid so formed in the upper vapour space 14 separate from the vapour under gravity and density, thereby producing sweetened gas in the upper vapour space 14. The liquids and solids then
5 separate further under density and gravity to the lower sour liquid collection zone 16 and the upper hydrocarbon liquid collection zone 18, producing a slurry of sour solids and sour liquids in the lower sour liquid collection zone 16 and hydrocarbon liquid in the upper hydrocarbon liquid collection
10 zone 18. Droplets and/or particles of sour species continuously fall through the upper hydrocarbon liquid collection zone 18 to the lower sour liquid collection zone 16. An interface 11 is formed between the hydrocarbon liquid and the sour liquid, as well as a gas-liquid interface 13
15 between the sweetened gas and the hydrocarbon liquid.

Where the sour gas is lean in condensable hydrocarbon components only a single liquid phase of substantially sour liquid may form in the lower sour liquid collection zone 16,
20 wherein a gas-liquid interface 15 between the sweetened gas and the sour liquid is formed. It will be appreciated, however, that the sour liquid may contain small amounts of condensable hydrocarbons which may be subsequently vapourised as the temperature of the sour liquid is raised to melt solid
25 sour species.

Sweetened gas may be withdrawn from the separator vessel 12 via outlet 22.

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The slurry of sour solids in sour liquid is then heated to a temperature at least marginally greater than the solidification temperature of the sour solids to convert the sour solids to the sour liquid in the lower sour liquid collection zone 16 of the separator vessel 12. Typically, the separator vessel 12 is provided with an immersion heater 30 which heats the slurry up to a temperature marginally greater than the melting point temperature of the sour solids. In this particular embodiment, the immersion heater 30 comprises the heat exchanger which cools the gas stream while heating the slurry. In small applications, the immersion heater 30 may comprise an electric immersion heater.

It is by reason of the heating of the sour liquid in the lower sour liquid collection zone 16 that the hydrocarbon liquid phase and the sour liquid phase are not only distinguished by density but by their respective temperatures. The upper hydrocarbon liquid phase is typically at a temperature close to the temperature maintained in the upper vapour space 14 (i.e. about -80 °C - -90 °C) whereas the lower sour liquid phase is maintained at a temperature approximately 5 °C above the freezing point of carbon dioxide, and is significantly warmer (i.e. typically at about -55 °C to -60 °C).

Operation of the apparatus to maintain and establish two distinct liquid phases is advantageous in order to prevent condensable hydrocarbons mixing with and being extracted along with the sour species. Additionally, the colder

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hydrocarbon liquid phase effectively insulates the upper vapour space 14, leading to easier maintenance of desired temperatures, a lower residual concentration of sour species in the upper vapour space 14, and improved separation of
5 sweetened gas and sour species. Provided the interface 11 between the hydrocarbon liquid and sour liquid can be maintained and is sufficiently spaced from the heater 30 in the lower sour liquid collection zone, entrainment of hydrocarbons in the sour liquid is minimized, and
10 consequently reboiling of hydrocarbons is minimized, thus reducing the amount of energy input required for the system.

The maintenance of two liquid phases in the separator vessel 12 allows the operator to withdraw hydrocarbon liquid from
15 the upper hydrocarbon liquid collection zone via outlet 24 and sour liquid from the lower sour liquid collection zone via outlet 26. Sour liquid may be directly pumped to a sequestration site, or disposed of for retail sale. Prior to sequestration or storage, the sour liquid may be used as a
20 cooling stream in any one or more of the heat exchangers of the apparatus 10 to conserve energy within the apparatus 10.

Withdrawing the hydrocarbon liquid and/or withdrawing the sour liquid is performed in a manner to maintain a
25 substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel. Preferably, the hydrocarbon liquid and/or the sour liquid are controllably withdrawn with respective first and second level control valve assemblies in response to signals received from one or
30 more probes and/or sensors disposed in the lower sour liquid

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collection zone and/or the upper hydrocarbon liquid collection zone and/or the upper vapour space of the separator vessel for determining the interface. Information from the probes and/or sensors is also used to maintain the interface 13 between the upper vapour space 14 and the hydrocarbon liquid, the depth of the hydrocarbon liquid phase so that the cooling/insulating effect between the upper vapour space 14 and the sour liquid is maintained, and the desired level of the interface 11 in the separator vessel 12.

10

Preferably, the interface 11 between the hydrocarbon liquid and the sour liquid is maintained at a desired level in the separator vessel 12 so as not to approach the heating means 30 in the lower sour liquid collection zone 16 of the separator vessel 12 and trigger vapourisation of hydrocarbons in the hydrocarbon liquid.

15

In the event that hydrocarbon vapour is generated from the sour liquid of the lower sour liquid collection zone 16, particularly in the proximity of the heater 30, the separator vessel 12 is preferably provided with the means 36 for directing this vapour to the upper vapour space 14, even more preferably the riser assembly 38 described above. Hydrocarbon vapour generated in the sour liquid collection zone 16 passes upwardly through the lower conical component 42 and the vertical component 40 and exit the vertical component 40 in the upper vapour space 14. In this way, the means 36 is configured to minimize disturbance of the interface 11 between the sour liquid and hydrocarbon liquid.

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The apparatus of the present invention, in its various embodiments, is configured to achieve effective control of the temperature of the one or more liquid phases in the separator vessel 12. The temperature of the one or more
5 liquid phases may be controlled by adjusting the current input of an electrical heater or by using a by-pass control valve in a process heat exchanger.

Continuous and stable operation of the apparatus and the
10 process described herein is achieved by effective control of the temperature and liquid levels of the one or more liquid phases formed in the separator vessel 12.

Effective control of the temperature in the one of more
15 liquid phases is not only required to sufficiently melt solid sour species to enable withdrawal of liquid sour species, but it is also required to prevent excessive boil off of liquid hydrocarbons which would significantly effect the upper vapour space 14 and composition of the sweetened gas in the
20 separator vessel 12.

Continuous melting of solids in the sour liquids collection zone 16 is important to avoid excessive solids accumulation therein which would cause blockage of liquid drain lines.
25 Additionally, it is preferable that there is continuous introduction and melting of solids in the sour liquid collection zone 16 at a controllable rate, and avoidance of sudden rises in liquid level, temperature disruption, and volume increase by solids which fall into the sour liquid

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collection zone after having accumulated on the walls of the separator vessel 12.

In the description of the invention, except where the context
5 requires otherwise due to express language or necessary
implication, the words "comprise" or variations such as
"comprises" or "comprising" are used in an inclusive sense,
i.e. to specify the presence of the stated features, but not
to preclude the presence or addition of further features in
10 various embodiments of the invention.

It is to be understood that, although prior art use and
publications may be referred to herein, such reference does
not constitute an admission that any of these form a part of
15 the common general knowledge in the art, in Australia or any
other country.

Numerous variations and modifications will suggest themselves
to persons skilled in the relevant art, in addition to those
20 already described, without departing from the basic inventive
concepts. All such variations and modifications are to be
considered within the scope of the present invention, the
nature of which is to be determined from the foregoing
description.

25

CLAIMS

1. An apparatus for separating a sour gas stream into
sweetened gas, liquid hydrocarbon, and sour liquid
5 comprising:

a separator vessel having an upper vapour space, a
lower sour liquid collection zone, and an upper
hydrocarbon liquid collection zone disposed between the
upper vapour space and the lower sour liquid collection
10 zone;

means for introducing the sour gas stream into the
upper vapour space,

the upper vapour space being arranged to operate
under conditions whereby introducing the sour gas stream
15 into the upper vapour space produces a mixture of sour
liquid and/or solids, methane vapour and hydrocarbon
liquid, the sour liquid and/or solids and the
hydrocarbon liquid separating under gravity and density
to the lower sour liquid collection zone and the upper
20 hydrocarbon liquid collection zone, respectively,
thereby producing sweetened gas in the upper vapour
space;

a heating means in the lower sour liquid collection
zone for melting sour solids that collect in the lower
25 sour liquid collection zone into sour liquid;

an outlet for withdrawing sweetened gas from the
upper vapour space;

an outlet for withdrawing hydrocarbon liquid from
the upper hydrocarbon liquid collection zone;

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an outlet for withdrawing sour liquid from the lower sour liquid collection zone;
and means for maintaining a substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel.

2. The apparatus according to claim 1, wherein the means maintains the substantially stable interface between the hydrocarbon liquid and the sour liquid at a desired level in the separator vessel.
3. The apparatus according to claim 1 or claim 2, wherein the means for introducing the sour gas stream into the upper vapour space may comprise an inlet in the upper vapour space of the separation vessel.
4. The apparatus according to claim 3, wherein a gas expansion device defines the inlet of the upper vapour space.
5. The apparatus according to any one of the preceding claims, wherein the means for introducing the sour gas stream into the upper vapour space further comprises means to introduce the sour gas stream into the upper vapour space with a swirl to aid separation of the mixture of sour liquid and/or solids, methane vapour and hydrocarbon liquid produced in the upper vapour space.
6. The apparatus according to any one of the preceding claims, wherein the heating means is a heater.

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7. The apparatus according to any one of the preceding claims, wherein the means for maintaining a substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel comprises a first level control valve assembly in fluid communication with the outlet in the lower sour liquid collection zone and a second level control valve assembly in fluid communication with the outlet in the upper hydrocarbon liquid collection zone.
8. The apparatus according to claim 7, wherein the first and second level control valve assemblies are operatively controlled in response to signals received from one or more probes and/or sensors disposed in the lower sour liquid collection zone and/or the upper hydrocarbon liquid collection zone and/or the upper vapour space of the separator vessel.
9. The apparatus according to claim 7 or claim 8, wherein the first and second level control assemblies maintain the substantially stable interface between the hydrocarbon liquid and the sour liquid at the desired level in the separator vessel.
10. The apparatus according to any one of claims 7 to 9, wherein the first and second level control assemblies maintain a substantially stable interface between the upper vapour space and the upper hydrocarbon liquid phase.

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11. The apparatus according to claim 10, wherein the first and second level control assemblies maintain the substantially stable interface between the upper vapour space and the upper hydrocarbon liquid phase at a desired level in the separator vessel.
12. The apparatus according to any one of the preceding claims, wherein the means for maintaining a substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel further comprises means for directing vapour generated in the sour liquid collection zone to the upper vapour space.
13. The apparatus according to claim 12, wherein the directing means is configured to minimize disturbance of the vapour-liquid interface and/or the liquid-liquid interface.
14. The apparatus according to claim 12 or claim 13, wherein the directing means comprises a riser assembly to facilitate fluid communication between the lower sour liquid collection zone and the upper vapour space.
15. The apparatus according to claim 14, wherein the riser assembly comprises a vertical component extending upwardly from a lower conical component, the lower conical component being disposed in the sour liquid collection zone and the vertical component extending through the hydrocarbon liquid collection zone and

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terminating in the upper vapour space of the separator vessel.

- 5 16. The apparatus according to claim 15, wherein the lower conical component is disposed above and proximal to the heating means.
- 10 17. The apparatus according to any one of claims 14 to 16, wherein the riser assembly is formed from material having low thermal conductivity.
- 15 18. The apparatus according to any one of claims 14 to 17, wherein the riser assembly is provided non-stick surfaces and downward sloping surfaces to prevent falling solids from accumulating.
- 20 19. The apparatus according to any one of claims 15 to 18, wherein the vertical component is configured to prevent sour solids from entering from the top.
- 25 20. The apparatus according to any one of the preceding claims, wherein the separator vessel is provided with an inlet disposed in the lower sour liquid collection zone, wherein the inlet is configured to introduce sour liquid into the lower sour liquid collection zone.
- 30 21. The apparatus according to any one of the preceding claims, wherein the means for maintaining a substantially stable interface between the hydrocarbon liquid and the sour liquid in the

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separator vessel further comprises a non-stick surface provided on interior wall(s) of the separator vessel.

- 5 22. The apparatus according to claim 21, wherein the non-stick surface extends continuously on the entire interior wall(s) of the separator vessel.
- 10 23. The apparatus according to claim 21, wherein the non-stick surface extends substantially over the interior wall(s) of the separator vessel disposed in the vapour space therein.
- 15 24. The apparatus according to any one of claims 21 to 23, wherein the non-stick surfaces is provided by coating or lining a surface of the separator vessel with a material capable of preventing solid accumulation on the separator vessel walls.
- 20 25. A process for separating a sour gas stream into sweetened gas, liquid hydrocarbon, and sour liquid comprising the steps of:
- 25 introducing the sour gas stream into an upper vapour space of a separator vessel operated under conditions to produce a mixture of sour liquid and/or solids, methane vapour and hydrocarbon liquid in the upper vapour space;
- 30 allowing the sour liquids and/or solids and the hydrocarbon liquid to separate under gravity and density to a lower sour liquid collection zone and an upper

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hydrocarbon liquid collection zone provided in the separator vessel, respectively, thereby producing a sweetened gas in the upper vapour space;

5 melting sour solids that collect in the lower sour liquid collection zone into sour liquid;

withdrawing sweetened gas from the upper vapour space;

withdrawing hydrocarbon liquid from the upper hydrocarbon liquid collection zone; and

10 withdrawing sour liquid from the lower sour liquid collection zone;

wherein the step of withdrawing the hydrocarbon liquid and/or the step of withdrawing the sour liquid is performed in a manner to maintain a substantially stable interface between the hydrocarbon liquid and the sour liquid in the separator vessel.

26. The process according to claim 25, wherein the step of withdrawing the sour liquid is performed in a manner to maintain the substantially stable interface between the hydrocarbon liquid and the sour liquid at a desired level in the separator vessel.

27. The process according to claim 25 or claim 26, wherein the step of withdrawing the sour liquid is performed in a manner to maintain a substantially stable interface between the upper vapour space and the upper hydrocarbon liquid phase.

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28. The process according to claim 25, wherein the step of withdrawing the sour liquid is performed in a manner to maintain the substantially stable interface between the upper vapour space and the upper hydrocarbon liquid phase at a desired level in the separator vessel.
5
29. The process according to any one of claims 25 to 28, wherein the process comprises heating the sour solids to a temperature at or just above the melting point of the sour solids.
10
30. The process according to any one of claims 25 to 29, wherein the step of withdrawing the hydrocarbon liquid and/or the step of withdrawing the sour liquid comprises controllably withdrawing the hydrocarbon liquid and/or the sour liquid with respective first and second level control valve assemblies in response to signals received from one or more probes and/or sensors disposed in the lower sour liquid collection zone and/or the upper hydrocarbon liquid collection zone and/or the upper vapour space of the separator vessel for determining the interface.
15
20
31. The process according to any one of claims 25 to 30, wherein the separator vessel is operated under a set of temperature and pressure conditions at which the sour species solidifies and/or a liquid condensate of sour species forms.
25

- 40 -

32. The process according to claim 31, the sour gas stream is cooled prior to introduction to the separator vessel to a temperature at or just below the temperature at which the sour species solidifies and/or condenses.
- 5
33. The process according to claim 32, wherein the step of cooling the sour gas stream comprises cooling and expanding the sour gas stream in one or more expansion steps.
- 10
34. The process according to claim 32, wherein the step of cooling the gas stream comprises effecting a direct heat exchange with a cooling stream.
- 15
35. An apparatus for separating a sour gas stream into sweetened gas and sour liquid comprising:
- a separator vessel having a vapour space and a sour liquid collection zone;
- a means for introducing the sour gas stream into the vapour space, the vapour space being arranged to operate under conditions whereby introducing the sour gas stream into the vapour space produces a mixture of sour liquid and/or solids, hydrocarbon vapour and, optionally, hydrocarbon liquid, the sour liquid and/or solids and the hydrocarbon liquid, if present, separating under gravity and density to the sour liquid collection zone, thereby producing sweetened gas in the vapour space;
- 20
- a heating means in the sour liquid collection zone for melting sour solids that collect in the sour liquid collection zone into sour liquid;
- 25
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an outlet for withdrawing sweetened gas from the vapour space;

an outlet for withdrawing sour liquid from the sour liquid collection zone;

5 and means for controlling a level of the sour liquid in the separator vessel.

36. The apparatus according to claim 33, wherein said means controls the sour liquid at a desired level in
10 the separator vessel.

37. The apparatus according to claims 33 or claim 36, wherein the means for controlling the liquid level in the separator vessel comprises a non-stick surface
15 provided on interior wall(s) of the separator vessel.

38. The apparatus according to claim 37, wherein the non-stick surface extends continuously on the entire interior wall(s) of the separator vessel.
20

39. The apparatus according to claim 37, wherein the non-stick surface extends substantially over the interior wall(s) of the separator vessel disposed in the vapour space therein.
25

40. The apparatus according to any one of claims 37 to 39, wherein the non-stick surface is provided by coating or lining a surface of the separator vessel with a material capable of preventing solid
30 accumulation on the separator vessel walls.

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41. The apparatus according to any one of claims 35 to
40, wherein the means for controlling the liquid
level in the separator vessel comprises a liquid
5 level control valve assembly in fluid communication
with the outlet in the sour liquid collection zone.

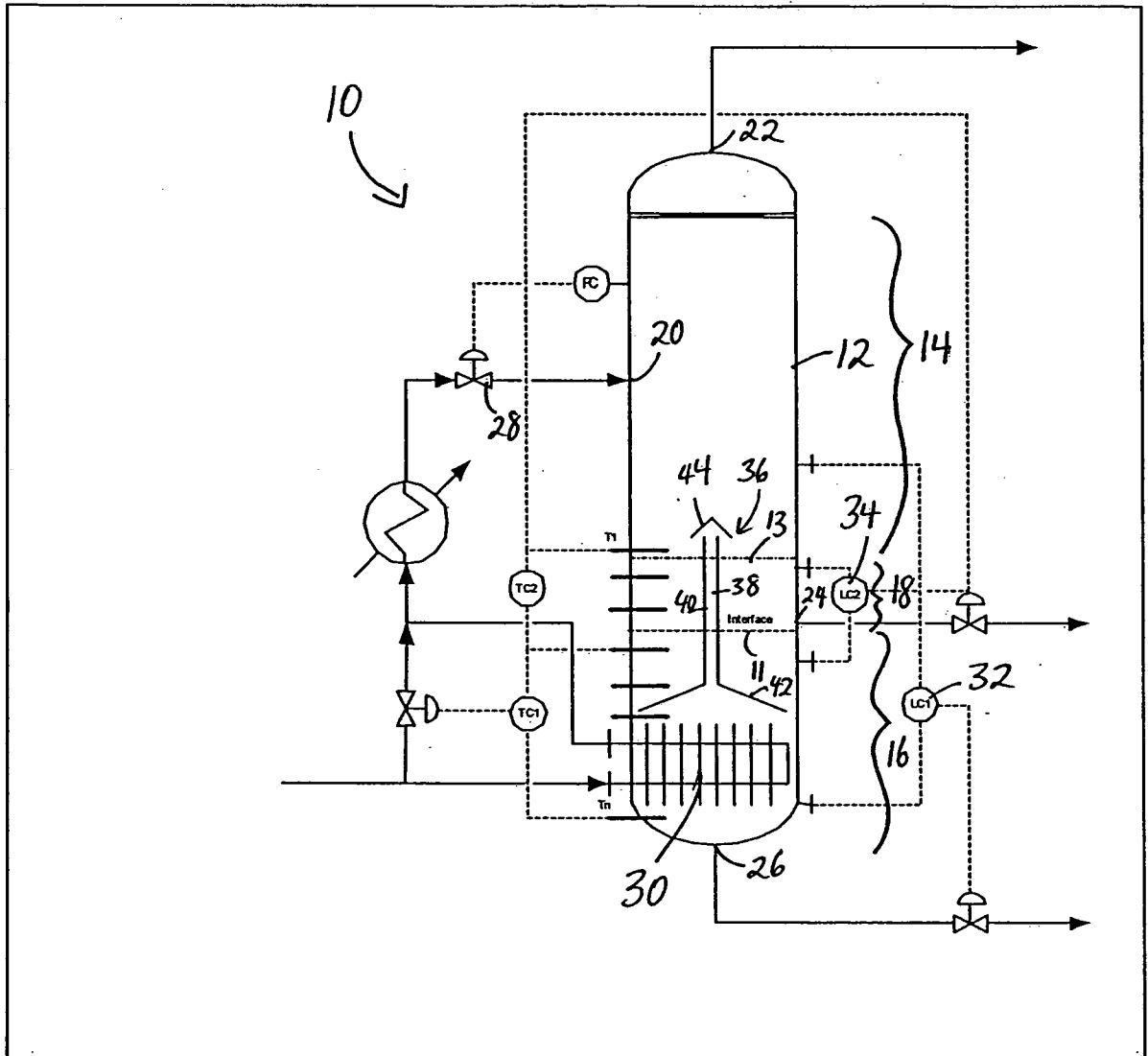


Figure 1

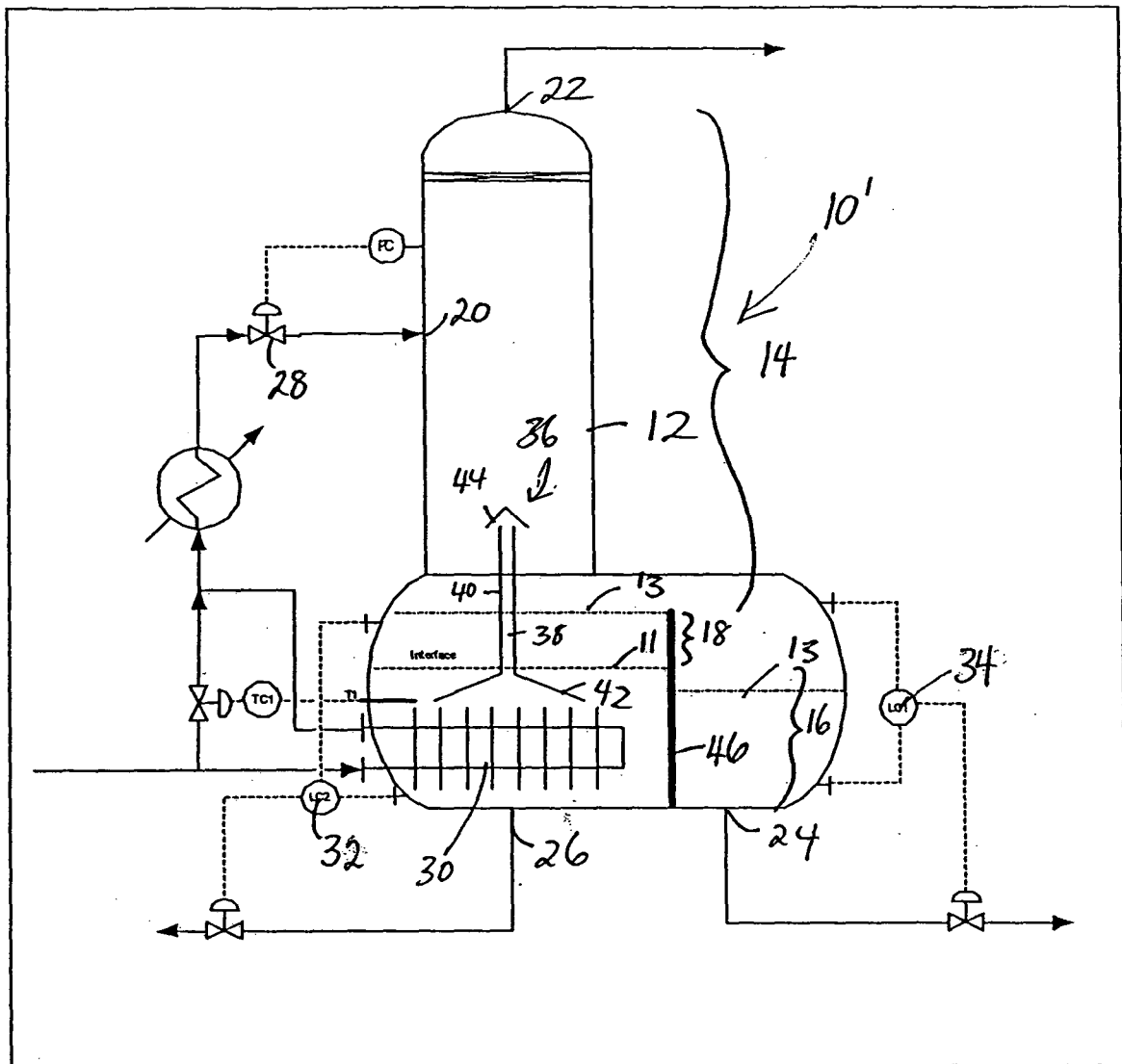


Figure 2

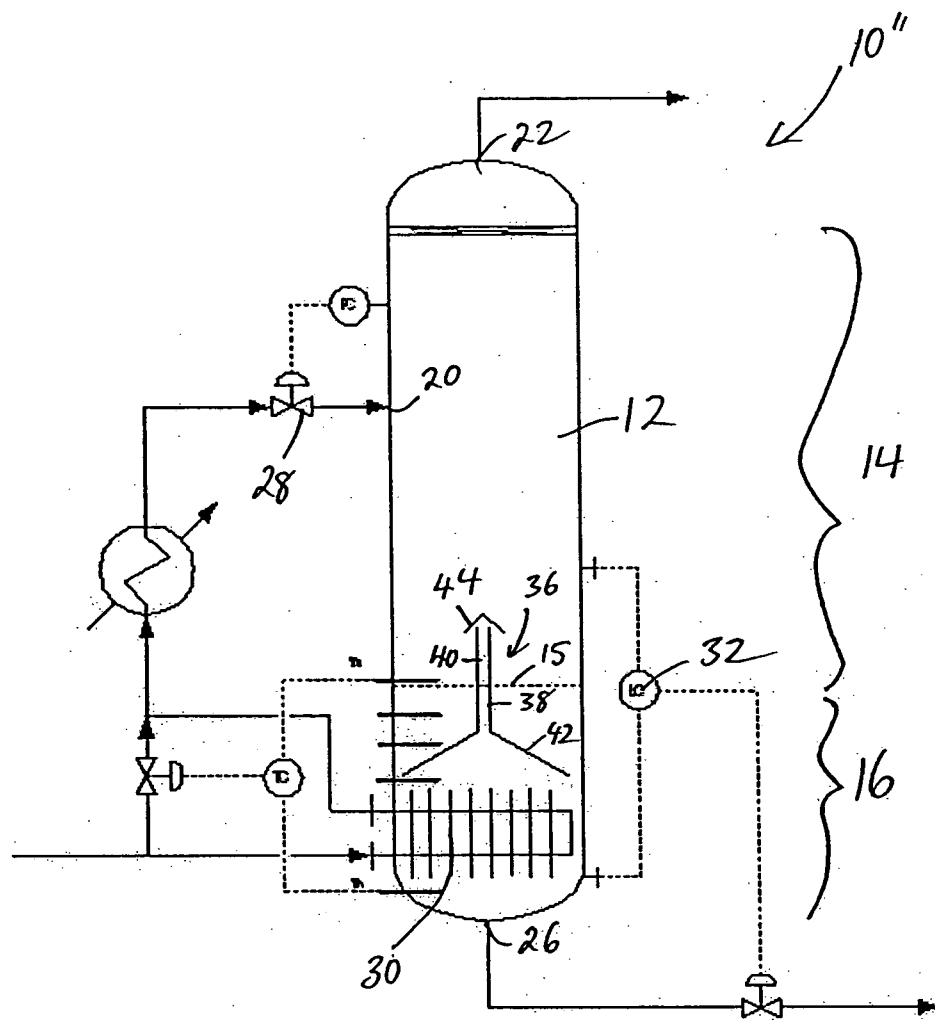


Figure 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2010/000723

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

F25J 3/08 (2006.01)

F25J 3/00 (2006.01)

F25J 3/06 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI IPC Marks (F25J3/IC/EC) KEYWORDS ((INTERFACE? OR LEVEL? OR BOUNDAR+) AND ((CONTROL OR REGULAT+) OR (SOUR+ OR CARBON_DIOXIDE? OR CO2 OR HYDROGEN_SUL[F,PH]IDE+ OR H2S) OR (NATURAL_GAS OR COAL_SEAM_GAS+ OR BIOGAS+ OR LANDFILL_GAS+) OR (NON_STICK, TEFLON+, POLYTETRAFLUOROETHYLENE, PERFLUOROALKOXY+, FLUORINATED_ETHYLENE_PROPYLENE+, +FEP+, PTFE+, PFA+) OR (OR_RISING, RISE+, TUB, CONE?, CONI+, VERTICAL+)))

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5819555 A (ENGDAHL) 13 October 1998 Column 4 lines 65-67, column 5 line 8 to column 6 line 11-20, figure 1	1-13, 20, 25-36, 41
A	US 4001116 A (SELCUKOGLU) 4 January 1977	
A	US 4187689 A (SELCUKOGLU ET AL) 12 February 1980	
A	US 3798918 A (MAHER ET AL) 26 March 1974	



Further documents are listed in the continuation of Box C



See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"E" earlier application or patent but published on or after the international filing date

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"O" document referring to an oral disclosure, use, exhibition or other means

"&"

document member of the same patent family

"P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search
16 August 2010

Date of mailing of the international search report 19 AUG 2010

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2010/000723

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member				
US	5819555	NONE					
US	4001116	CA	1024061	DE	2608680	FR	2302766
		GB	1516924	JP	51112480	NL	7602201
US	4187689	NONE					
US	3798918	CA	956228				
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.							
END OF ANNEX							