

INLINE GAS LIQUID SEPARATION SYSTEM WITH A SHARED REJECT VESSEL

Field of invention

5 The present invention is concerned with a system for gas-liquid separation wherein rejection streams of degasser and deliquidizer units are combined in a shared reject vessel.

Background of invention

10 Gas-liquid separation equipment and systems have a long range of industrial applicability including the oil and gas industry. Subsea separation, including deep-water subsea separation, involves particular challenges with respect to weight and size of the equipment to be used.

15 The weight and seize limitations involves challenges with compact separation systems, the systems have to be compact with low weight. Additionally the systems should be robust i.e. have reduced need for maintenance. The system must however be accessible for intervention.

20 A separation process design should be robust such that the separation process can be operated safe and reliable with respect to specifications, and also the quality of the gas and liquid outlets should be delivered in accordance with specifications. A simple and robust process design also enables conventional and robust process control configurations.

25 If the gas and liquid outlets are not within the quality specifications downstream equipment such as pumps and compressors may be damaged.

The inlet flow may be uncertain and varying, both in amount and composition, and it is thus necessary that the system has good and easy turndown and start-up abilities as well as flexible operating ranges.

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Operating in deep water it is an advantage that the system can be classified and approved according to pipe code instead of pressure vessel.

Examples of multiphase separation systems are found in e.g. WO 00/40834 A1, GB 2 394 737 A and US 6,197,095 B1.

WO 00/40834 A1 relates to a method for removing condensables from a natural gas stream, at a wellhead downstream of the wellhead choke thereof. It is provided a method for removing condensables from a natural gas stream at a wellhead, the method comprising the steps of: (A) inducing the natural gas to flow at supersonic velocity through a conduit of a supersonic inertia separator and thereby causing the fluid to cool to a temperature that is below a temperature/pressure at which the condensables will begin to condense, forming separate droplets and/or particles; (B) separating the droplets and/or particles from the gas; and (C) collecting the gas from which the condensables have been removed, wherein the supersonic inertia separator is part of the wellhead assembly downstream of the wellhead choke. There is also provided a device for removing said condensables from said natural gas that is part of the wellhead assembly downstream of the choke.

GB 2 394 737 A discloses a fluid separation system for separating a multiphase fluid from a well comprising at least one first gravity separator and at least one second gravity separator, and valves which allow the first and second gravity separators to be set in parallel or series formation depending on the properties of the fluid and process conditions. Valves can be selectively opened or closed to allow the first separators to operate in parallel formation followed by a secondary re-separation process through second separators which are also operated in parallel formation.

In US 6,197,095 B1 a subsea multiphase fluid separation system and method are disclosed where the system is a modular construction wherein the modules are secured in a single frame to be lowered as a unit to the seabed. The system utilizes reliable cyclonic operation. The sequence of the process steps is designed to make the system more efficient as compared to surface separating systems and thereby permit a more compact size as is desirable for subsea operations. The method of operation includes up to five basic process steps with the initial step is one embodiment including cyclonically separating solids. A second stage is directed to

cyclonically removing bulk gas from the liquid in either a cyclone or auger separator. A liquid-liquid hydro-cyclone for the third stage acts to pre-separate the fluid either by separating and/or by coalescing oil droplets in a water continuous stream and/or water droplets in an oil continuous stream. A forth stage gravity separator is significantly smaller for the flow throughput as compared to surface separating systems due to the earlier separation processes and due to the option of subsequent oily-water separation in a de-oiling liquid-liquid hydro-cyclone.

Summary of the invention

The invention is defined in the patent claims.

In one aspect, there is provided a gas-liquid separation system comprising a splitter configured to separate the inlet stream from a well stream into liquid and gaseous phases, the splitter having an outlet for a liquid phase to a liquid continuous line to an inline degasser configured to drive separation of gas and liquid by centripetal acceleration, where the clean liquid exits through a liquid outlet pipeline and the gas with some liquid are extracted in a reject line and flow into a reject vessel, and the splitter having an outlet for the gaseous phase to a gas continuous line to an inline deliquidizer configured to drive separation of liquid and gas by centripetal acceleration, where the clean gas exits through a gas outlet pipeline and the liquid with some gas are extracted in a reject line and flow into the reject vessel, wherein the reject vessel is configured for separation by gravity.

In another aspect, there is provided a method of operating a gas-liquid separation system, comprising transferring an inlet stream from a well stream to a splitter facilitating separation of a liquid phase and a gaseous phase, transferring the liquid continuous stream into a degasser where the fluid is set into spin and the centripetal acceleration drives separation of gas and liquid, the clean liquid exits through a liquid outlet and gas and some liquid are extracted in the reject line and flow into a reject vessel, transferring the gas continuous stream into a deliquidizer where the fluid is set into spin and the centripetal acceleration drives separation of liquid and gas, the clean gas exits through a gas outlet and liquid and some gas are extracted in the reject line and flow into the reject vessel, the mixed liquid and gas from the

reject lines are separated by gravity in the shared reject vessel, the degassed liquid is combined with the liquid outlet and the dry gas is combined with the gas outlet.

Brief description of the drawings

5 Figure 1 shows an embodiment of the system according to the invention. The inlet stream 1 from the well stream is split in a gas continuous line and a liquid continuous line in for instance a phase splitter, a bulk separator, either compact or conventional. The gas continuous stream is cleaned i.e. de-liquidized, preferably in an Inline DeLiquidizer 2, and the clean gas exit through the gas exit and the reject stream enters the reject vessel 4, similar the liquid continuous stream is de-gasified, preferably in an Inline DeGasser 3, and the clean liquid exit through the liquid exit and the reject stream enters the reject vessel 4.

10 The reject vessel 4 is then used to clean the remaining gas and liquid, combining the gas with the gas outlet of the deliquidizer 2 and the liquid with the degasser 3 liquid line.

Figure 2 shows an embodiment of the invention with multiple DeGassers 3 and Deliquidizers 2 in parallel and wherein the reject streams enters a shared reject vessel 4.

Detailed description of the invention

20 The present invention is particularly advantageous in subsea application. Even if the invention is described herein by way of example with reference to such subsea application it should be understood that the invention is not limited to such subsea use but is also applicable for use both topside on an offshore installation as well as
25 on land.

Inline separators suffer inherently of low turndown abilities, as it is the inlet flow momentum that facilitates the centripetal acceleration (or g-force) driving the separation.

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Turndown can be handled by having two or more deliquidizers and two or more degassers in parallel. In this way one can isolate, i.e. cut off, one or more of the units to handle turndown.

- 10 For very low turndown, i.e. 25% to 0% of the nominal designed flow rate, this system configuration according to the invention handles this by closing the outlet valves 5 and 6 such that all of the inlet flow to the inline separators (DeGasser and DeLiquidizer) are routed to the shared reject vessel. The flow rate is then low enough for the shared reject vessel and first stage bulk separator to separate and
- 15 produce a clean gas and liquid stream without the use of the inline separators.

- In this invention the degrading performance of inline separators during low flow rate can be overcome by using multiple DeGassers and Deliquidizers in parallel and closing of the outlet valves 5 and 6 during very low flow rates. When 5 and 6 are
- 20 fully closed all of the flow is routed to the shared reject vessel.

- The system is equipped with control valves which are used to regulate the flow rate of the different streams. These valves may be regulated independent of each other, although they should be regulated with regard to the flow rate and composition of
- 25 the inlet stream 1.

The system can be controlled and regulated with means and methods generally known in the art.

- This system design solution will ensure a complete and overlapping operational envelope and ensure good separation quality and be within specification during
- 30 start-up and shut-down and other abnormal operational scenarios where the flow rate is reduced, without the use/need of complex process control, recirculation or

cross connecting process streams which tend to reduce the robustness and reliability of such compact separation systems.

5 The separation system design according to the invention provides a compact gas-liquid separation process. The solution is very attractive as a deep water subsea application, but also as a compact separation design for topside use.

10 The system design is particularly useful in combination with Inline equipment. In this context Inline equipment should be understood to mean equipment as described in OTC 23223, Paper prepared for presentation at the Offshore Technology Conference held in Houston, Texas, USA, 30 April-3 May 2012 and SPE 135492, Paper prepared for presentation at the SPE Annual Technical conference and Exhibition held in Florence, Italy, 19-22 September 2012. The use of such Inline equipment is limited due to rigid system dynamics and susceptibility to flow
15 variations. When using a single vessel for reject streams from both degasser and deliquidizer, the control complexity of the system is reduced and operating with a larger total reject stream is possible, thus increasing the robustness of the system.

20 Combining the reject streams of the Inline separators into a combined reject vessel enables the total separation system to be semi-compact, use standard process control solutions, be tolerant to inlet flow and pressure variations, and still achieve good quality outlet streams.

25 The separation system design according to the invention is used in a compact gas-liquid separation process. It can be used deep water subsea, even ultra deep water (below 3000 meters) or as a high pressure topside application. The invention provides a low weight system with robust design with respect to process control, and can thus handle start-up and shut-down of the separation process. In certain embodiments of the invention the system can also be designed using pipe code
30 classification.

The gas and liquid inlet stream enters 1 which separates the stream into a liquid and a gas continuous stream. The gas continuous stream flows to a deliquidizer 2, where

the fluid is set into spin and the centripetal acceleration drives separation of gas and liquid. Clean gas exits 2 through the gas outlet, while the liquid extracted from the gas together with a portion of the gas is extracted in the reject line and flow into 4. The liquid continuous stream from 1 flows towards a degasser 3 where the fluid is

5 set into spin and the centripetal acceleration drives separation of gas and liquid. Clean liquid exits 3 via the liquid outlet, while the gas and some liquid are extracted in the reject line and flow into 4. The mixed liquid and gas streams from the rejects 2 and 3 are separated by gravity in a shared vessel 4, where dry gas is combined with the gas outlet, and the degassed liquid is combined with the liquid outlet.

10 Combining the rejects into a shared vessel 4 enables this separation system to produce two clean phases and at the same time making this system more flexible to process disturbances and easier to control than using a DeLiquidizer and a DeGasser with separate boot and scrubber sections respectively, both which would require

15 separate control systems. The purpose of the de-liquidizer 2 and de-gasser 3 is to reduce the gas and liquid load into the shared reject vessel 4 and thus enable an ultra compact size and footprint, and still achieve the specified gas and liquid outlet quality.

20 Utilizing a shared reject vessel 4, de-liquidizer 2 and de-gasser 3 can be operated more conservatively compared to common design philosophy for inline equipment, meaning that slightly more reject than what is required to achieve the specified separation efficiency should be extracted to the reject line and into the shared reject vessel 4. This will ensure good tolerance to inlet flow and pressure disturbances.

25 In an embodiment of the invention a gas-liquid separation system is provided comprising a splitter configured to separate the inlet stream from a well stream into liquid and gaseous phases, to drive separation of gas and liquid where the clean liquid exits through a liquid outlet pipeline and the gas with some liquid are

30 extracted in a reject line and flow into a reject vessel, and the splitter having an outlet for the gaseous phase to a gas continuous line to a deliquidizer configured to drive separation of liquid and gas where the clean gas exits through a gas outlet

pipeline and the liquid with some gas are extracted in a reject line and flow into the reject vessel.

5 In other embodiments of the invention the shared reject vessel is a conventional separator or an ID pipe section.

In a preferred embodiment of the invention the degasser is an InLine DeGasser and/or the deliquidizer is an InLine DeLiquidizer.

10 In an embodiment of the invention gas continuous stream is flown into one or more deliquidizers, and the liquid continuous stream is flown into one or more degassers, and all the reject streams are combined in a shared reject vessel. In systems wherein there are two or more deliquidizers and/or degassers respectively they are configured in parallel as illustrated in figure 2.

15 The number of degassers and deliquidizers are independent of each other e.g. there may be one degasser and two or more deliquidizers in parallel, two or more degassers in parallel and one deliquidizer, three degassers in parallel and five deliquidizers in parallel.

20 The shared reject vessel is in one embodiment of the invention configured to receive rejects from additional process units, particularly an additional subsea process unit e.g. other subsea separators or liquid precipitates from compressors. In this embodiment the reject vessel comprises at least one connection to a stream from an additional process unit.

25 In an embodiment of the invention a system is provided wherein a gas outlet from the reject vessel is connected to the gas outlet from the deliquidizer. A system is further provided wherein a liquid outlet from the reject vessel is connected to the liquid outlet from the degasser.

30 The system according to the invention comprises control valves (5, 6). The flow rate through the control valves (5, 6) are regulated in accordance with the flow rate and

composition of an inlet stream 1. The inlet flow will vary in both flow rate and composition e.g. ratio between gaseous and liquid phase.

5 The invention also provides a method of operating a gas-liquid separation system, comprising transferring an inlet stream from a well stream to a splitter facilitating separation of a liquid phase and a gaseous phase, transferring the liquid continuous stream into the degasser where the fluid is set into spin and the centripetal acceleration drives separation of gas and liquid, the clean liquid exits through a liquid outlet and gas and some liquid are extracted in the reject line and flow into a reject vessel, transferring the gas continuous stream into the deliquidizer where the fluid is set into spin and the centripetal acceleration drives separation of liquid and gas, the clean gas exits through a gas outlet and liquid and some gas are extracted in the reject line and flow into the reject vessel, the mixed liquid and gas from the reject lines are separated by gravity in the shared reject vessel, the degassed liquid is combined with the liquid outlet and the dry gas is combined with the gas outlet.

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In an embodiment of the method the stream flows are controlled by valves.

CLAIMS

1. A gas-liquid separation system comprising
a splitter configured to separate the inlet stream from a well stream into liquid and gaseous phases, the splitter having an outlet for a liquid phase to a liquid continuous line to an inline degasser (3) configured to drive separation of gas and liquid by centripetal acceleration, where the clean liquid exits through a liquid outlet pipeline and the gas with some liquid are extracted in a reject line and flow into a reject vessel (4), and the splitter having an outlet for the gaseous phase to a gas continuous line to an inline deliquidizer (2) configured to drive separation of liquid and gas by centripetal acceleration, where the clean gas exits through a gas outlet pipeline and the liquid with some gas are extracted in a reject line and flow into the reject vessel (4), wherein the reject vessel (4) is configured for separation by gravity.
2. The system according to claim 1, comprising two or more degassers in parallel and/or two or more deliquidizers in parallel.
3. The system according to claim 1, wherein the reject vessel is a conventional separator.
4. The system according to any of the preceding claims, wherein the reject vessel comprises at least one connection to streams from another process unit.
5. The system according to any of the preceding claims, wherein a gas outlet from the reject vessel is connected to the gas outlet from the deliquidizer.
6. The system according to any of the preceding claims, wherein a liquid outlet from the reject vessel is connected to the liquid outlet from the degasser.

7. The system according to any of the preceding claims, wherein the system comprises control valves (5, 6).

8. The system according to claim 7, wherein the outlet flows controlled by control valves (5, 6) are regulated in accordance with the flow rate and composition of an inlet stream.

9. A method of operating a gas-liquid separation system, comprising transferring an inlet stream from a well stream to a splitter facilitating separation of a liquid phase and a gaseous phase, transferring the liquid continuous stream into an inline degasser (3) where the fluid is set into spin and the centripetal acceleration drives separation of gas and liquid, the clean liquid exits through a liquid outlet and gas and some liquid are extracted in the reject line and flow into a reject vessel (4), transferring the gas continuous stream into an inline deliquidizer (2) where the fluid is set into spin and the centripetal acceleration drives separation of liquid and gas, the clean gas exits through a gas outlet and liquid and some gas are extracted in the reject line and flow into the reject vessel (4), the mixed liquid and gas from the reject lines are separated by gravity in the shared reject vessel, the degassed liquid is combined with the liquid outlet and the dry gas is combined with the gas outlet.

10. The method according to claim 9, wherein the stream flows are controlled by valves.