

Separation System Using Heat of Compression

The present invention relates to a subsea system, and especially to a subsea system where at least some of the heat in the fluid flow as a result of compression of the fluid flow, is used to heat a fluid flow before it enters a separation stage. This subsea system is especially relevant for gas rich fluid flows or multiphase fluid flows.

Background of the invention

There are several systems known to provide separation of a well stream into different phases and thereafter transport the well stream to shore or platform. The present invention provides a device and method for providing a separation system with increased capacity in a case with a gas rich fluid stream or a multiphase fluid stream.

Summary of the invention

The invention is defined in the independent claim, while the dependent claims describe other embodiments of the invention.

According to the invention there is provided a subsea system comprising a separator with a fluid inlet line and at least one outlet line, the subsea system also comprises a compression unit for a gas rich fluid flow with an inlet line and an outlet line. The compression unit may be a pump, a multiphase pump, a compressor or other kind of element increasing the pressure in the fluid and at the same time increase the temperature in the fluid due to the compression. The system is further provided with a connection between the outlet line from the compression unit and the inlet line of the separator, providing heat transfer from at least a part of the fluid in the compression unit outlet line with the separator inlet line.

This gives a separation system that uses heat from gas compression or gas-liquid compression (also denoted multiphase pumping or wet gas compression) to increase the temperature in the process flow entering the separation station, so that the viscosity of the process flow is reduced and the separation efficiency of all involved phases therefore can be increased. The process fluids entering the separation station, heated by the compressed fluids, will have a reduced propensity of depositing wax or other substance onto the internal surfaces of separators and any process equipment for produced water treatment.

An added benefit from this system is the reduction in temperature of the fluid in the compression unit outlet line as heat is transferred to the inlet line of the separator and therefore from the fluid in the compression unit outlet line.

The temperature increase associated with the compression of fluids will be reduced by means of heat transfer, thus enabling further downstream processing of separated

or non-separated process phases, when such processing is aided by the reduced temperature.

According to the invention, a possible embodiment is to provide a heat exchanger for heat transfer between the compression unit outlet line fluid and the separator inlet line fluid.

One may possibly use all the fluid in the compression outlet line for the heat transfer. This meaning guiding all the fluids at the compression outlet line through a heat exchanger. Another possibility is to provide a separator unit at the outlet of the compression unit to separate out a part of the fluid at the outlet of the compression unit to lead through a heat exchanger with the fluid at the inlet of the separator.

There is also the possibility of having two heat exchangers in parallel downstream of the separator arranged downstream of the compressor, one for each fluid phase out of the separator. Another possibility is to have a flow splitter at the outlet line of the compressor unit, to take only a part of the fluid through the heat exchanger.

One may guide all the fluid from the compressor outlet line through the heat exchanger with the separator inlet line or only parts of the fluid and then possibly let the rest of the fluid bypass the heat exchanger. One possibility is to then combine the flows again after the heat exchanger, or another possibility is to lead one of the flows into another fluid line.

Another possibility is to take a part of the flow at the outlet from the compression unit and mix this with the well stream at the inlet of the separator. This part of the flow may be a part of a multiphase flow or a part of a phase divided flow. The temperature increase in the process fluid can be achieved by recirculation of and commingling with process fluid that has been compressed in a pump or compressor, thus avoiding the use of a heat exchanger. In other words, bleed off a part of the compressed process fluid, relieve the pressure and guide it directly into the process stream to heat this. The bleed off may take place after or in a mixer to make sure an even distribution of phases in the two or more flows.

The compression unit in the form of a multiphase pump or compressor may, according to one embodiment, be placed after, or with other words, downstream of the separation station. By using a system according to the invention, one gets increased efficiency in the separator, but also cooling of the fluid flow after the compression unit. The separation station may comprise several stages and sub-processes. The multiphase pump or compressor can be placed between separation stages or between process parts, according to the requirements of these stages and process parts.

Any gas in the process fluid can be separated from other phases after the pump or compressor, according to the requirements of the stages and process parts. By doing this, one may have a heat exchanger at the inlet of the separator with only one phase in the flow through the heat exchanger. Another possibility is to have one phase through the heat exchanger and at least a part of the flow not flowing through the heat exchanger bled down in pressure and introduced in the process flow, to

increase the temperature with mixing. Another possibility is to have this phase not flowing through the heat exchanger in a bypass line and remixed with the split phase downstream of the heat exchanger.

Any gas in the process fluid can be intermediately separated from the other phases upstream of the compression unit.

The pump or compressor may alternatively be placed upstream of the separation station, thus improving separation efficiency through a temperature increase, and/or preventing wax or other temperature influenced deposition on or inside process equipment.

Any cooler between or after separation stages or other process parts can be used to reduce the process fluid temperature, according to the requirements of equipment downstream of the cooler.

There is also the possibility of providing the system with additional sources for heating the fluid stream at the inlet of the separator. This may for instance be electric heating sources. Another possibility is to heat exchange the cooling fluid of the motor of the compression unit with the fluid at the inlet of the separator.

Detailed description of the invention

The invention will now be explained with non-limiting embodiments with reference to the attached drawings where;

Fig. 1 is a sketch of some possible configurations of the invention

Fig. 2 is a possible embodiment where the invention is used

Fig. 1 is a sketch of possible principles of the invention, only elements relevant for the understanding of the invention is shown, as there may be many additional elements in the system. In fig. 1 there is a subsea system comprising a separator 1 with an inlet line 2 and an outlet line 3. The inlet line is connected to an upstream source which may be the wellhead or another upstream subsea unit as for instance a separator. There would normally be an additional outlet line from the separator 1, which is not shown in the drawings as it is not directly relevant for the invention. In addition there is a compression unit 4 in the subsea system, with an inlet line 5 and an outlet line 6. The compression unit may be a compressor or a multiphase pump. The inlet line 5 of the compression unit may as indicated with the dotted line 10 be connected directly with the outlet line 3 from the separator 1. Another possibility is to have the inlet line 5 be connected to another fluid source. The outlet line 6 is guided into a heat transfer unit 7 which is connected to the inlet line 2 of the separator 1. This heat transfer 7 unit may be a heat exchanger or it may be a mixer. In the case with a heat exchanger 7, the fluid in the outlet line 6 of the compressor 4 may in one embodiment be guided through the heat exchanger 7. Exiting this heat exchanger, the fluid would be cooled while heating the fluid in the inlet line 2 towards the separator 1.

Another possibility is to provide a unit 8 in the form of a separator in the outlet line 6 downstream of the compression unit 4. This separator would separate the outlet fluid in the outlet line 6 into two streams and possibly guide one of these through

the heat exchanger 7 and another in a bypass line 9. These may downstream be connected again or lead to different equipment subsea. Another possibility is to have the unit 8 as a splitter, splitting the outlet line 6 fluid into two or more streams, whereof one or several are guided through a heat exchanger 7.

- 5 Another possibility is to have the unit 8 split of a part of the fluid in the outlet line 6 and then introduce this into a mixer 7 after the pressure is bled off to mix with the fluid in the inlet line of the separator 1.

Also the inlet line 2 to the separator may be divided with one part through a heat exchanger and one part as a bypass.

- 10 Fig. 2 shows one possible embodiment of implementing the invention. The separation process comprises a first separation stage and a second separation stage, in the form of primary and secondary separation, possibly arranged in a first and second separator. There is arranged a first compression unit 12 downstream of the second separator and there may possibly also be arranged a compression unit 11
- 15 upstream of at least one of the separators, in the figures indicated with a compression unit 11 upstream of the first separator. The fluid exiting the second separator is pressurized in one compression unit 12 and is then lead through a first heat exchanger positioned between the first and second separator and then further through a possible heat exchanger upstream of the first stage separation. The heat
- 20 exchanger upstream of the first separation stage is positioned between the separator and a possible upstream compression unit . There is the possibility of just using one heat exchanger and the position being one of the above mentioned. There is also the possibility of using just one compression unit in this configuration. Produced water from the first and second separation stages are guided into a produced water
- 25 treatment unit. Oily reject 15 may from this treatment unit be introduced into the flow upstream of the first or second separation stage. The water to be reinjected is lead out from the treatment unit to a water reinjection pump 13. Part of the flow from the pump may be reintroduced 16 in to the treatment unit.

- Here the compression or multiphase pumping 11, 12 is located at different steps in
- 30 the process, in this case upstream of the first processing step and after the secondary separation step.

- The first compression unit 11 increases the stream temperature so that e.g. the risk of wax precipitation in the oil and water treatment parts of the process is reduced. The temperature increase also enhances the separation efficiency, possibly reducing
- 35 the size and weight of the separator vessels. Furthermore, with two stage pumping, the injection water pump 13 size can be reduced. Heated injection water also has a lower viscosity, which may improve water permeation into the reservoir.

- The advantage of multiphase compression in one or several stages with heat exchange is not only that the stream leaving the subsea process for further
- 40 processing or transportation is cooled. Provided that the required injection water pressure is higher than the upstream process pressure, there is water pressure available for recirculation back into the produced water treatment process. Single

step multiphase compression upstream of the separation process would not facilitate this.

With the arrangement in Fig 2, the temperature of the stream 14 is maximized, since water is removed from stream 14, the gas volume fraction into pump or compressor 12 is maximized because water is removed, thus increasing the temperature out of 12, gas is included in the hot side of the heat exchange, and this gas has a relatively high heat capacity at normal processing pressures.

A further arrangement, not shown in Fig 1 or Fig 2, would be to split the gas and oil stream (out of last step pump) and lead it either as separate streams of gas and liquid, or as split multiphase streams, to two or more heat exchangers.

Another variety of this arrangement, also not shown in Fig 1 or Fig 2, is to cool part of the stream out of pump or compressor 12 with seawater, and not heat exchange this part with the process stream.

Another variety of this arrangement, also not shown in Fig 1 or Fig 2, is to have a bypass line around each heat exchanger in order to control the fluid flow rate entering the heat exchanger and thus optimize the amount of heat transferred in each device. The heat exchangers could also be arranged in parallel or in series. In Fig 2 the downstream processing may be a cooling unit for precipitation of wax out of oil, so that a pipeline will not be clogged with wax as oil cools. The heat exchange aids a downstream process like this. To prevent top-of-the-line corrosion, the heat exchange could also be part of a cooling sequence to condense water from the gas phase, to obtain controlled mixing with a corrosion inhibited aqueous phase. In Fig 2 the oily reject stream 15 from the produced water treatment may be recombined with the process stream up- or downstream of each separation stage.

The invention has now been explained with reference to the attached drawings and embodiment. There may be made alternations and modifications to these embodiments that are within the scope of the invention as defined in the attached claims. There is also the possibility of combining features from the different embodiments to another embodiment of the invention.

CLAIMS

1. Subsea system comprising a separator (1) with an inlet line (2) and at least one outlet line (3) and a compression unit (4) with an inlet line (5) and an outlet line (6) and a heat transfer unit (7) for transferring heat between at least a part of a fluid in the inlet line (2) of the separator (1) and at least a part of a fluid in the outlet line (6) from the compression unit (4).
2. Subsea system according to claim 1, wherein the compression unit (4) is a multiphase pump.
3. Subsea system according to claim 1, wherein the compression unit (4) is a compressor.
4. Subsea system according to one of the preceding claims, wherein the heat transfer unit (7) is a heat exchanger.
5. Subsea system according to one of claims 1-3 comprising a splitter downstream of the compression unit (4) to split out a part of fluid in the outlet line (6) of the compression unit (4), and guide said part of the fluid into the heat transfer unit, the heat transfer unit being a mixer (7), to mix with the fluid in the inlet line (2) upstream of the separator (1), during use.
6. Subsea system according to one of the preceding claims, wherein the inlet line (5) of the compression unit (4) is connected to the outlet line (3) of the separator (1).
7. Subsea system according to one of the preceding claims, wherein the outlet line (6) of the compression unit (4) is connected to a downstream wax precipitation unit.
8. Subsea system according to one of the preceding claims, wherein the heat transfer unit (7) is provided with an additional heat source.
9. Subsea system according to the one of the preceding claims, wherein the system comprises at least a second compression unit arranged upstream of the separator.
10. Subsea system according to one of the preceding claims, wherein the system comprises at least two separation stages, with a first and second separator.
11. Subsea system according to one of the preceding claims 1-4 or 6-10, wherein the heat transfer unit (7) is a heat exchanger (7), which heat exchanger (7) is arranged

downstream of the compression unit (4) that is arranged downstream of one separator (1), and upstream of at least one other separator to heat exchange a process fluid upstream of a separation stage.

- 5 12. Subsea system according to one of the preceding claims 10 or 11, wherein the system comprises a heat exchanger (7) upstream of each separation stage.
- 10 13. Subsea system according to one of the preceding claims 1-4 or 6-12, wherein the subsea system comprises an additional separator upstream of the heat exchanger (7) and downstream of the compression unit (4), such that the heat exchange takes place in parallel with split phases or one phase is bypassing the heat exchanger (7) or mixed into a process fluid.
- 15 14. Subsea system according to one of the preceding claims 1-4 or 6-12, wherein the subsea system comprises an additional separator upstream of the heat exchanger (7), and a bypass line (9) for at least one phase around the heat exchanger (7).