the oil polishing unit comprises an inlet, a first outlet for a clean oil phase, and a second outlet for a reject stream, the inlet in fluid communication with the second outlet of the bulk separation unit;
the water polishing unit comprises an inlet in fluid communication with the first outlet of the bulk separation unit, a first outlet for a reject stream, and a second outlet for a clean water phase, wherein: a first conduit connects the second outlet of the oil polishing unit upstream of, or to, the water polishing unit, and a second conduit connects the first outlet of the water polishing unit upstream of, or to, the oil polishing unit, and wherein the first and/or second conduit comprises a pressurizing device for increasing the pressure of a reject stream, and wherein the oil polishing unit comprises a second inlet, for receiving a reject stream during use, and a third conduit connects the first outlet of the water polishing unit with said second inlet, and/or
a fourth conduit connects the second outlet of the oil polishing unit with the water polishing unit.

In one embodiment of the system of the invention, the second outlet of the oil polishing unit and/or the first outlet of the water polishing unit is connected upstream of, or to, the bulk separation unit.

In yet an embodiment of the system of the invention, a reject treatment unit is arranged downstream of at least one of the second outlet of the oil polishing unit and the first outlet of the water polishing unit, and upstream of the bulk separation unit.

In yet an embodiment of the system of the invention, gas evolved in the oil polishing unit or in the water polishing unit, during use, is pressurized separately from a liquid reject stream and returned upstream of, or to, the bulk separation unit.

In yet an embodiment of the system of the invention, a liquid level of the oil polishing unit and/or the water polishing unit is arranged such that a reject stream may be returned upstream of, or to, the oil polishing unit, the water polishing unit and/or the bulk separation unit, without the use of a pressurizing device, during use.

In yet an embodiment of the system of the invention, the oil polishing unit comprises a cyclonic separator device and/or a gravity separator.

In yet an embodiment of the system of the invention, the oil polishing unit comprises an inline electrostatic coalescer (IEC) arranged upstream of the cyclonic separator device and/or the gravity separator.

In yet an embodiment of the system of the invention, the water polishing unit comprises at least one cyclonic separator, preferably the water polishing unit comprises two or more serially connected cyclonic separators.

In yet an embodiment of the system of the invention the water polishing unit comprises at least one further element suitable for separating oil from water, such as a flotation unit, a membrane separator or a gravity separator, said element arranged downstream of the cyclonic separator(s).

In yet an embodiment of the system of the invention, the clean water phase is suitable for injection into a reservoir during use, and preferably contains less than 100 ppm oil.

In yet an embodiment of the system of the invention the clean oil phase is suitable for transport during use, and preferably contains less than 3% water by volume.

In yet an embodiment of the system of the invention the reject treatment unit comprises at least one component which during use will provide an enhanced separation of individual phases of a reject stream when returned to the bulk separator, the enhanced separation obtained by for instance chemical injection, heating and/or droplet coalescing.

In yet an embodiment of the system of the invention, at least parts of the clean oil phase is pressurized by a pressurizing device, such as a pump or ejector.

In a further aspect, the invention provides a method for subsea separation of a product stream, comprising the steps of:

- leading the product stream to a bulk separation device, wherein the product stream is separated into a water phase, an oil phase and a gas phase; and
- leading the water phase to a water polishing unit and obtaining an oil reject stream and a clean water phase, the clean water phase suitable for injection into a reservoir and preferably containing less than 100 ppm oil; and
- leading the oil reject stream to the oil polishing unit; and
- leading the oil phase to an oil polishing unit and obtaining a water reject stream and a clean oil phase, the clean oil phase suitable for long distance oil transport and preferably containing less than 3% water by volume; and
- leading the water reject stream to the water polishing unit.

In the context of the present invention, the term "clean oil phase" is intended to mean an oil phase comprising typically less than 3% of water by volume, and the term "clean water phase" is intended to mean a water phase comprising less than 100 ppm by volume of oil.

The term "water polishing" is intended to mean a process wherein a water phase is purified by removing oil until the water contains less oil than required for injection, for example 100 ppm.

The term "oil polishing" is intended to mean a process wherein an oil phase is further purified by removing water, until the oil contains less water than required, typically below 3%.

The term "pressurizing device" is intended to mean any suitable type of device able to increase the pressure of a fluid flow, such as a pump, ejector or compressor.

Short description of the drawings

Fig. 1 shows a schematic drawing of one embodiment of a system according to the invention, wherein the reject streams are returned to the bulk separator.

Fig. 2 and 3 show schematic drawings of two embodiments of a system according to the invention, wherein the reject streams are not returned to the bulk separator.

Claims

1. A subsea separation system for separating a product stream, comprising:
a bulk separation unit (1),
an oil polishing unit (2),
and a water polishing unit (3),
the bulk separation unit (1) comprises an inlet (4) for the product stream, a first outlet (5) for a water phase, a second outlet (6) for an oil phase, and a third outlet for a gas phase (15);
the oil polishing unit (2) comprises an inlet (7), a first outlet (8) for a clean oil phase, and a second outlet (9) for a reject stream, and the inlet is in fluid communication with the second outlet (6) of the bulk separation unit (1);
the water polishing unit (3) comprises an inlet (11) in fluid communication with the first outlet (5) of the bulk separation unit, a first outlet (12) for a reject stream, and a second outlet (13) for a clean water phase, and a first conduit connects the second outlet (9) of the oil polishing unit upstream of, or to, the water polishing unit (3), and a second conduit connects the first outlet (12) of the water polishing unit upstream of, or to, the oil polishing unit (2), and wherein the first and/or second conduit comprises a pressurizing device (14,16) for increasing the pressure of a corresponding reject stream, and wherein the oil polishing unit comprises a second inlet (10), for receiving a reject stream during use, and a third conduit connects the first outlet (12) of the water polishing unit (3) with said second inlet (10),
and/or
a fourth conduit connects the second outlet (9) of the oil polishing unit with the water polishing unit (3).

2. A subsea separation system according to claim 1, wherein the second outlet (9) of the oil polishing unit and/or the first outlet (12) of the water polishing unit is connected upstream of, or to, the bulk separation unit (1).

3. A subsea separation system according to claim 1 or 2, wherein a reject treatment unit (17,18) is arranged downstream of the second outlet (9) of the oil polishing unit and/or the first outlet (12) of the water polishing unit, and upstream of the bulk separation unit (1).

4. A subsea separation system according to any of claims 1 to 3, wherein gas evolved in the oil polishing unit (2) or the water polishing unit (3) is pressurized separately from the corresponding reject stream and returned upstream of, or to, the bulk separation unit (1).

5. A subsea separation system according to any of claims 1 to 4, wherein a liquid level of the oil polishing unit (2) and/or the water polishing unit (3) is arranged such that the corresponding reject stream may be returned upstream of, or to, the oil polishing unit (2), the water polishing unit (3) and/or the bulk separation unit (1), without the use of a pressurizing device (14, 16).

6. A subsea separation system according to any of claims 1 to 7, wherein the oil polishing unit (2) comprises a cyclonic separator device and/or a gravity separator, the oil polishing unit (2) preferably comprises an inline electrostatic coalescer (IEC) arranged upstream of the cyclonic separator device and/or the gravity separator.

7. A subsea separation system according to any of claims 1-6, wherein the water polishing unit (3) comprises at least one cyclonic separator, preferably two or more serially connected cyclonic separators.

8. A method for subsea separation of a product stream, comprising the steps of:
   - leading the product stream to a bulk separation device (1), wherein the product stream is separated into a water phase, an oil phase and a gas phase; and
   - leading the water phase to a water polishing unit (3) and obtaining an oil reject stream and a clean water phase, the clean water phase suitable for injection into a reservoir and preferably containing less than 100 ppm oil; and
   - leading the oil reject stream to an oil polishing unit (2); and
   - leading the oil phase to the oil polishing unit (2) and obtaining a water reject stream and a clean oil phase, the clean oil phase suitable for long distance oil transport and preferably containing less than 3% water by volume; and

- leading the water reject stream to the water polishing unit (3).

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