

IMPROVED SEPARATOR AND PROCESS

This invention relates to a method and apparatus for separating two different at least partially immiscible fluids having different densities in a pressurised vessel or pressurised vessel assembly. In particular, the process and apparatus will be described with reference to separation of water and an oil from mixtures thereof. The term oil is herein used to refer to water immiscible liquids which may be in the form of silicones or organic liquids such as hydrocarbons, lubricants and waxes.

Background

With the advent of stricter environmental standards, there is a need for highly efficient methods of separating oil and water from mixtures of the two which occur, for example in the bilge water of a naval vessel. Internationally agreed standards require that mixtures be separated to reduce the oil content of the water to less than 15 parts per million. It is presently very difficult to achieve these standards, particularly at sea where stable emulsions of oil in water are formed due to the presence of surfactants from detergents or additives and the continual movement of the ship produces unfavourable conditions for separation equipment.

A number of types of separators are being produced which rely on a variety of separation techniques including gravity separation and filtration using a variety of filters such as paper filters or polymeric cartridge filters. Despite the considerable research which has been undertaken to improve the performance of filters, the commercially available filters fail to provide a consistent high performance when used for long periods of time under adverse conditions.

Gravity separators having an oil/air interface within the separating vessel have been used but we have generally found them to be incapable of handling high flow rates. This problem is also exacerbated when separating

high viscosity oils. Gravity separators also tend to be inefficient on moving platforms as movement causes splashing at the oil air interface.

International application PCT/AU96/00307 discloses an apparatus
5 which provides separation of oil water mixtures by pumping the mixture through a filter. While the apparatus provides efficient separation of oils, the present inventors have found that the efficiency is reduced when heavy oils are present in significant amounts. We have found that heavy oils tend to clog the filter making separation less efficient.

10

There is a need for a separator and process which has the capacity to handle significant flow rates and provides efficient separation of different oils under a range of conditions.

15 The invention provides an apparatus for separation of at least partly immiscible liquid components from a mixture. The apparatus including:

- a closed separation vessel;

- an inlet for introducing the mixture under pressure to the vessel;

- separation means comprising baffle means defining a flow path to
20 allow at least partial separation of the mixture within the vessel to provide a first phase and a second phase;

- a first phase collection space having a first vertical extremity defined by an interior vertical extremity of the vessel, generally the top,

- a plurality of outlets including an outlet for the first phase from said
25 collection space and an outlet for said second phase;

- an outlet valve for controlling discharge of the first phase from the outlet;

- interface detection means for detecting the presence of an interface of
the first phase with the other contents of the vessel and disposed at level
30 within the vessel which is vertically spaced from said first vertical extremity and adapted to control said valve such that when the volume of said first phase in the first phase collection space provides an interface at the

interface detection means the valve is actuated to discharge at least a portion of the volume of said first phase from said vessel.

In the preferred embodiment of the invention the apparatus is used for
5 oil/water separation and the oil is a hydrocarbon. The first phase is the hydrocarbon phase adjacent the top of the vessel.

The outlets generally include second outlet to provide an outlet for a second phase, typically the aqueous phase.

10

The liquid in the vessel is under pressure from the incoming mixture. As a result even viscous oil is readily discharged from the first outlet under control of phase interface detector. This is a significant advantage when compared with open vessels used in prior art separators.

15

Open vessels tend to produce emulsions due to mixing of air and liquid particularly when movement produces splashing. We have found that by substantially eliminating an air-liquid interface and maintaining the liquid under pressure difficulties encountered with separation on a moving platform
20 are reduced.

Preferably the second outlet provides an outlet for a water phase from adjacent the bottom of the separation vessel. Generally at least one of the outlets will be open during operation of the apparatus. For example, in one
25 embodiment the water phase outlet is open allowing continuous flow of water from the second outlet until the volume of oil phase results in activation of the interface detection means. Opening of the first outlet (oil outlet) may be accompanied by partial or full closure of the water phase outlet to provide sufficient pressure to rapidly deliver all or part of the oil phase from the
30 collection space. The first outlet valve may be opened for a predetermined time to allow a predetermined portion of the separated first phase to be delivered from the outlet.

As the vessel is maintained under pressure from the incoming mixture the separated phases may be discharged from the outlets without additional pumps.

- 5 We believe it is advantageous that the fluid pressure drop between the pump outlet and atmosphere substantially occurs after the separator vessel.

The baffle means defines a flow path along which the mixture flows. The flow path provided by the baffles will provide a residence time sufficient to allow
10 at least partial separation into two phases. The baffle means will typically provide a first surface spaced apart from a second surface for inducing separation of the oil and water phases. The baffle means will generally provide a central vertical passage.

- 15 The baffle arrangement may be helical or spiral in shape or comprise a multiplicity of coaxial truncated cones. The oil component adheres to the surface of the baffle which is typically the undersurface.

A range of baffle arrangement can be used. For example one
20 preferred arrangement is the spiral baffle described in International Application PCT/GB92/00558. A further example of baffle means are the cones disclosed in International Application No. PCT/GB91/01867, conical plates of SU-3592288, (Derwent Abstract 85-208418/34) and the stationary plates of Netherlands Publication 015028 (Derwent Abstract AN
25 77-497794/28).

A preferred baffle arrangement is disclosed in Australian Patent 685659 and corresponding International Application No. PCT/AU95/00460 the contents of which are herein incorporated by reference. In this
30 arrangement the flow path is typically such that a convection current or similar flow such as a rotating flow, countercurrent flow, recycling flow or the like is produced in which the direction of flow along the flow path is in one direction through or past a first part of the baffle and in a second direction

around or through a second part of the baffle. It would be expected that use of baffle arrangement in a pressure system would significantly change the characteristics of the convection currents or similar flow leading to diminished separation capacity.

5

The baffle means preferably includes one continuous spiral section or an assembly of spiral sections. The spiral sections when used will typically be stacked so that the central opening defined by the spiral sections forms a central passage which is preferably approximately vertical.

10

In the preferred embodiment the spiral baffle includes a plurality of peripheral flanges extending at the outer edge of the spiral baffle so as to interrupt vertical flow between the baffle and inside of the vessel wall. The peripheral flanges preferably extend for an angle of at least 90° and most preferably about 120° and about the axis of the spiral baffle. The baffles are preferably staggered. The positions of the baffle between the peripheral flanges allow passage of liquid between the baffle and vessel wall however the staggered baffles interrupt downward flow to direct flow in a spiral.

20

Surprisingly we have found that the efficiency of separation is enhanced under pressure particularly where the outer edge of the baffle means abuts the wall of the vessel.

25

The interface detection means will be adapted to detect an interface between a volume of water and a volume of oil. In operation the collected oil phase will be removed periodically so that the interface detection means may become coated in oil. The interface detection means will generally be a probe which can sense water or a water/oil interface through a coating of oil. The examples hereinafter describe a test for determining whether a probe is

30

suitable.

Generally the interface detection means will be a capacitive probe and the most preferred is the POINTEK CLS 100 capacitive probe (Milltronics Ltd.).

In a further aspect the invention provides a method of separating oil and water from mixtures thereof the process including the steps of:

5 feeding a mixture to be separated under pressure to a closed separation vessel via an inlet;

providing a flow path for the mixture the flow path being defined by a baffle means and being sufficient to at least partially separate the mixture into a first phase and a second phase,

10 providing a collection space for the first phase adjacent the top of the vessel;

providing an interface detection means at a level spaced from the top of the vessel wherein when the volume of the collected first phase is sufficient to provide an interface of the oil phase at the level of the interface detection means a valve is activated to provide discharge of at least a portion of the
15 collected first phase from the vessel.

A second discharge outlet may be provided for discharge of the second phase. The method may involve discharging the second phase while collecting a first phase and restricting or ceasing discharge of the second phase during
20 discharge of the first phase.

In a further aspect the invention provides an oil/water separator comprising a vessel for separation of a mixture of oil and water into phases and an oil/water interface detection means for controlling the discharge of
25 accumulated oil wherein when said interface detection means is inserted onto a high density oil at a temperature of 4°C and removed the detection means will detect water when placed therein.

The invention will now be described with reference to the
30 accompanying drawing. In the drawings:

Figure 1 shows an oil/water separation apparatus in accordance with the invention.

Figure 2 shows a spiral baffle formed of a stack of spiral sections for use in the apparatus of Figure 1.

The apparatus (10) includes a closed separator vessel or chamber (20); a pump (30) for feeding the mixture to be separated to the vessel and a polisher (40) for removing further minor amounts of oil remaining in the water phase after preliminary separation.

The pump (30) introduces the mixture to be separated to the separator vessel (20) adjacent a bottom wall (21) via inlet (22). Baffle means (23) in the form of a substantially continuous helix arrangement (as shown in Figure 1 of PCT/AU95/00460 and described in the specification of the International application with reference to Figure 1 thereof) is located within the vessel. The maximum outer diameters of the baffle means of baffle (23) abut the outside (24) of the wall (25) of the vessel (20) so that there is no substantial gap. The helical nature of the baffle means (23) also provides a central passage (26).

The mixture contacts the baffle and is imparted with a swirling or circular motion passing about and through the baffle and droplets of oil collect and coalesce on the baffle and rise to collect in a collection space (27) at the top of the vessel. The oil collection space fills with oil thereby displacing the mixture below so that an interface between the oil and mixture moves in a downward direction. Probes (28) are provided at a space from the top (29) of the vessel and when the level (31) of the interface drops to at or below the probe a probe detects the interface and activates a valve (32) to open an outlet (33) for the oil.

During collection of the oil phase the aqueous phase is discharged adjacent the bottom of the vessel (21) via water discharge outlet (34). The detection of an interface (31) by the probe (28) may also activate water outlet valve (35) to restrict or close the outlet (34). Restriction or closure of the water outlet (34) during discharge of the oil allows pressure to be

maintained within the vessel to provide effective flow of even dense and viscous oils.

The baffle means of Figure 1 is made up of a continuous spiral (40) made up of spiral units (50) as depicted in Figure 2. The spiral (50) has a maximum diameter of 300mm corresponding with the inner diameter of the vessel wall and the side walls (51) of the spiral (50) are approximately 45-55° included from the horizontal. The upper extremity of the unit forms a circular opening (52). The units are stacked to form a continuous spiral or helix using vertical posts (53) passing through holes (54) in the peripheral portion (55) of the spiral unit (50).

The effectiveness of the spiral is enhanced by using peripheral flanges (56) which diverge horizontally from the baffle and interrupt flow between the spiral wall (51) and vessel wall (24) shown in Figure 1. Relief portions (57) between the peripheral flanges (56) allow passage of liquid but the circumferential spacing of peripheral flanges means that downward flow between the baffle and wall is interrupted at every second to fifth flight of the spiral to direct flow along the spiral. In the particular example shown in Figure 2 a repeating pattern is established. Looking between two of the three vertical posts (53) it is seen that the vertical displacement of the flanges (56) is staggered when adjacent 120° sectors are compared.

The discharge of water phase from water phase outlet (34) may carry small amounts of oil and further processing by polisher (40) is desired. The polisher includes a vessel (41) containing filter cartridges (42) which may be of the type described in International Application No. PCT/AU96/00307 or copending Provisional Application PP6200 of 28 September 1998.

The invention will now be more fully described with reference to the accompanying examples. It should be understood, however that the following description is illustrative only and should not be taken in any way as a restriction on the generality of the invention described above.

Example 1

A pressurised vessel assembly according to this invention was set up as shown in Figure 1.

- 5 The pump was a Seepex pump with a capacity (water) of 12 Litres/minute provided by Seeberger GmbH of Bottrop, Germany.

The piping was 25mm (= 1 inch) throughout.

- 10 The dimensions of vessel 1 were: height = 1.5 meters, id = 30cm, volume = 105 litres.

The dimensions of vessel 2 were: height = 1.1 meter, id = 30cm, volume = 70 litres.

15

The top probe in vessel (20) was a Pointek CLS 100 capacitive level probe located 120mm down from the top of the vessel.

0

- 20 This probe gave different signals when immersed in bulk water or bulk oil. When the probe detected water (this corresponded to the normal operating mode), the water discharge line from vessel (20) was opened and the oil discharge line was closed. When the probe (28) detected bulk oil (this happened when a significant head of separated oil had developed), the water discharge line from vessel (20) was closed and the oil discharge line
- 25 was opened. When the probe again detected bulk water, a pause of 10 seconds was set, after which the water discharge line (33) from vessel (20) was again opened and the oil discharge line closed.

- 30 The bottom probe in vessel (20) was also a Pointek CLS 100 capacitive level probe and was located 200mm down from the top of the vessel. It acted as a fail-safe device: when this probe detected oil, the system was switched off.

In accordance with Figure 2, 33 cone shaped spiral sections approximately 12mm apart were inserted in vessel (20) according to the teachings of PCT/AU96/00460. However in contrast to the teaching of PCT/AU96/00460 the outer edge of the baffles abutted the vessel wall. The dimensions of the cones were: diameter 30cm, cone apex angle 100°. The cone shaped spiral sections were fabricated from polyvinyl chloride.

The cartridges in vessel (40) was filled with glass wool, and each had the following dimensions: 300mm id, 360mm length.

10

A variety of oil/water mixtures were fed to the system at approx 11 Litres/minute, according to the following protocols:

15	Campaign 1	Oil = distillate fuel oil, relative density 0.83 @ 15°C Temperature = 10°C																
20		<table><tr><th>Period</th><th>Oil/water ratio</th></tr><tr><td>0 - 5 minutes</td><td>100% water</td></tr><tr><td>5- 10 minutes</td><td>100% oil</td></tr><tr><td>10 - 50 minutes</td><td>1 % oil, 99% water</td></tr><tr><td>50 - 90 minutes</td><td>25% oil, 75% water</td></tr><tr><td>90- 100 minutes</td><td>100% oil</td></tr><tr><td>100 - 115 minutes</td><td>100% water</td></tr><tr><td>115-295 minutes</td><td>Repeat cycles from 25% oil, 75% water to 100% water, and back again - cycle time 15 minutes</td></tr></table>	Period	Oil/water ratio	0 - 5 minutes	100% water	5- 10 minutes	100% oil	10 - 50 minutes	1 % oil, 99% water	50 - 90 minutes	25% oil, 75% water	90- 100 minutes	100% oil	100 - 115 minutes	100% water	115-295 minutes	Repeat cycles from 25% oil, 75% water to 100% water, and back again - cycle time 15 minutes
Period	Oil/water ratio																	
0 - 5 minutes	100% water																	
5- 10 minutes	100% oil																	
10 - 50 minutes	1 % oil, 99% water																	
50 - 90 minutes	25% oil, 75% water																	
90- 100 minutes	100% oil																	
100 - 115 minutes	100% water																	
115-295 minutes	Repeat cycles from 25% oil, 75% water to 100% water, and back again - cycle time 15 minutes																	
25																		
30	Campaign 2	Oil = distillate fuel oil, relative density = 0.83 ~ 15°C Temperature = 35°C Other conditions as in Campaign 1																
	Campaign 3	Oil = residual fuel oil relative density = 0.98 @ 15°C,																

viscosity = 220 centistokes ~ 37.8°C

Temperature = 10°C

Other conditions as in Campaign 1

- 5 Campaign 4 Oil = residual fuel oil,
relative density = 0.98 @ 15°C
Viscosity = 220 centistokes @ 37.8°C
Temperature = 35°C
Other conditions as in Campaign 1

10

The quantity of oil passed in each campaign was approx 600 Litres, and the glass wool cartridges in vessel (40) were replaced between campaigns.

- 15 No adjustments were carried out to the pressurised vessel assembly between any of the campaigns. In all of the campaigns, it was found that

(a) The level of oil in the clean water discharge from vessel (40) was always less than 5 ppm.

20

(b) The oil caught in vessel (40) at the end of a campaign was less than 50 mls in volume.

(c) The level of water in the discharged oil was less than 2%.

25

(d) The flow rate was significantly greater than that recommended for a vertical gravity settler containing cones of the dimensions utilised in vessel (20).

- 30 (e) The oil discharge rate was significantly greater than in a vertical gravity settler as described in PCT/AU95/00460 containing cones of the dimensions utilised in vessel (20) but wherein the outer edges of the baffles are spaced from the wall of the vessel.

Example 2

Information on choice of oil-water level detection probe for use in a pressurised oil-water separating device.

- 5 A variety of probes is available for fluid level detection inside a vessel
 e.g. Omron E7B-111 capacitive probe
 Pointek CLS100 capacitive probe
 Danfoss EVS1 capacitive probe

10 When using a probe for oil point level detection in a situation when the
oil/water interface advances and retreats, it is likely that the probe will
become coated with oil, particularly if the oil is viscous. In this case it is
advantageous if the probe can sense bulk water through an oil coating, and the
following test can be used to select an appropriate probe:

- 15 Take a viscous high-density residual fuel oil and place it in a fridge
(ARC). Insert the probe into the residual oil and withdraw it - it will be covered
with up to 5mm of thick fuel oil. Insert this coated probe into a bucket of water,
and check if the probe reads water (rather than oil).

- 20 The Pointek CLS100 probe passes this test.

Example 3

The following separators were compared under a range of conditions:

- 25 Model 1 - "Hodge" Separator Victor Mini Sep" brand bilge water
separator for use in shipboard oil separation.

Model 2 - Pressure separator with perforated plates and oil/water
interface probe according to Example 2.

- 30 Model 3 -Separator according to Figure 1 of International Application
PCT/AU95/00460.

Model 4 - Separator according to Example 1 of the present invention.

The comparative results are shown in Table 1 below:

TABLE 1

Feature	Model 1	Model 2	Model 3	Model 4
Satisfactory detection of oil/water interface	No	Yes	No	Yes
Capacity to discharge oil promptly	Good	Good	Poor	Good
Capacity to treat viscous low density oil	Poor	Good	Poor	Good
Capacity to separate $d > 0.99$ relative density oils	Poor	Poor	Good	Good
Capacity to handle high flow rates	Good	Good	Poor	Good
Capacity to provide a clean oil effluent stream	Poor	Poor	Good	Good
Avoidance of splashing when unit is jolted or moved (i.e. no oil/air interface)	Good	Good	Poor	Good
Fluid pressure drop between pump outlet and atmosphere substantially occurs after coalescing vessel	Yes	Yes	No	Good
Number of pumps requires for coalecer & polisher system	One	One	* Three	One
Minimal adjustments are necessary for various oil types	No	No	No	Yes

5

* For the non pressurised gravity separator three pumps are required as follows:

1. To introduce liquid into the vessel.
2. To pump the water discharge component to point of destination
(eg. overboard)
- 5 3. To pump oil discharge component to its point of destination
(eg. storage vessel).

10 It is to be understood that various alterations, modifications and/or
additions may be introduced into the separator and process described without
departing from the spirit or ambit of the invention.

Claims:

1. An apparatus for separation of at least partly immiscible liquid components from a mixture. The apparatus including:
 - 5 a closed separation vessel;
an inlet for introducing the mixture under pressure to the vessel;
separation means comprising baffle means defining a flow path to allow at least partial separation of the mixture within the vessel to provide a first phase and a second phase;
 - 10 a first phase collection space having a first vertical extremity defined by an interior vertical extremity of the vessel;
a plurality of outlets including an outlet for the first phase from said collection space and an outlet for the second phase;
an outlet valve for controlling discharge of the first phase from the
15 outlet;
interface detection means for detecting the presence of an interface of the first phase with the other contents of the vessel and disposed at level within the vessel which is vertically spaced from said first vertical extremity and adapted to control said valve such that when the volume of said first
20 phase in the first phase collection space provides an interface at the interface detection means the valve is actuated to discharge at least a portion of the volume of said first phase from said vessel.
2. An apparatus according to claim 1 for oil/water separation wherein
25 the oil is a hydrocarbon and said first phase is the hydrocarbon phase adjacent the top of the vessel.
3. An apparatus according to claim 2 wherein a second outlet provides an outlet for the aqueous phase adjacent the bottom of the vessel.
- 30 4. An apparatus according to claim 2 comprising an aqueous stream outlet and control means operable to provide continuous flow of water from

This Sheet Has Been Replaced



the second outlet until the volume of oil phase results in activation of the interface detection means.

5. An apparatus according to claim 4 wherein said control means
5 provides partial or full closure of the water phase outlet to thereby produce sufficient pressure to deliver all or part of the oil phase from the collection space.

6. An apparatus according to claim 5 wherein the control means
10 provides opening of the first outlet for a predetermined time to allow a predetermined portion of the separated first phase to be delivered from the first outlet.

7. An apparatus according to claim 2 wherein the baffle means
15 provides a first surface spaced apart from a second surface for inducing separation of the oil and water phases such that such that a convection current or similar flow such as a rotating flow, countercurrent flow, recycling flow or the like is produced in which the direction of flow along the flow path is in one direction through or past a first part of the baffle and in a second
20 direction around or through a second part of the baffle.

8. An apparatus according to claim 7 wherein the baffle is helical or spiral in shape.

25 9. An apparatus according to claim 7 wherein the baffle means has a plurality of peripheral flanges extending at an angle of at least 90° C about the axis of the spiral baffle to interrupt flow between the baffle and inside of the vessel wall.

30 10. An apparatus according to claim 9 wherein the flanges about the inside of the wall of the vessel.

This Sheet Has Been Replaced



* C L M S *

11. An apparatus according to claim 1 wherein the interface detection means is a capacitive probe.

12. A method of separating oil and water from mixtures thereof the process
5 including the steps of:

feeding a mixture to be separated under pressure to a closed separation vessel via an inlet;

providing a flow path for the mixture the flow path being defined by a baffle means and being sufficient to at least partially separate the mixture into a
10 water phase and an oil phase,

providing a collection space for oil first phase adjacent the top of the vessel and for the water phase adjacent the bottom of the vessel;

providing an interface detection means at a level spaced from the top of the vessel wherein when the volume of the collected oil phase is sufficient to
15 provide an interface of the oil phase at the level of the interface detection means a valve is activated to provide discharge of at least a portion of the collected oil phase from the vessel.

13. A method according to claim 11 including the steps of discharging
20 the water phase while collecting a oil phase and restricting or ceasing discharge of the water phase during discharge of the oil phase.

14. An apparatus according to claim 1 wherein said interface detection means for controlling the discharge of accumulated oil operates so that
25 when said interface detection means is inserted onto a high density oil at a temperature of 4°C and removed the detection means will detect water when placed therein.

15. An apparatus according to claim 1 substantially as herein described
30 with reference to the drawings.

16. A method according to claim 12 substantially as herein described with reference to the drawings.



This Sheet Has Been Replaced

