

INTERFACE AND MUD CONTROL SYSTEM AND METHOD FOR REFINERY DESALTERS

BACKGROUND OF THE INVENTION

5 This invention relates to systems and methods used in crude oil production. More specifically, the invention relates to methods for treating and controlling a first solid-laden water layer or “rag” that accumulates at the oil/water interface within separation, dehydration or desalting equipment and a second solid-laden layer or “mud” that accumulates at the bottom of the separation, dehydration, or desalting equipment.

10 Once oil is produced it must be dehydrated and desalted to reduce the corrosion effect on production systems such as transportation carriers, pipelines, and refineries. The dehydration and desalting done at the oil producing facility is capable of removing the majority of the water and salts prior to delivery to a refinery. Once the oil is at the refining it is desalted again to reduce the salts to even lower and less corrosive levels. In
15 addition to the water and dissolved salts carried by the oil, there may be a large quantity of solids ranging in size from very small sub-micron particles or fines to larger particles such as sands. The larger particles are readily removed by the oil production facility leaving the finer particles to be removed at the refinery.

 In general, the smallest particles may contribute to the stability of an oil-water
20 emulsion by forming a barrier around the water droplets thus preventing droplet coalescence and separation. Water droplets that are surrounded by these fines may be large enough to settle in the electrostatic desalter, but they are hindered from coalescing by the fines. The effect is for this solid-laden water layer to accumulate at the oil-water interface as a “rag.” As this rag layer collapses the fines settle to the bottom of the vessel
25 to form a “mud” layer where they must be removed periodically by a mud wash system.

This mud wash system consists of a set of spray nozzles that disperse a volume of fresh water into the desalter for the purpose of agitating the mud so it can be effectively removed from the desalter. Two primary methods for mud removal are practiced. One method is to do a timed mud wash where the vessel is washed only periodically as
5 determined by the unit operator. The frequency depends on the solids (mud) loading and may be once per day or once per week, as examples. The disadvantage of periodic mud wash is that it sends high levels of oil wet solids to the water treatment facility where it must be handled for disposal. These periodic injections of oil wet solids can initiate an upset in the water quality.

10 The other method is a semi-continuous mud wash where sections of a vessel are washed sequentially. Upon the completion of all sections, the sequence is restarted. The advantage of a semi-continuous wash is to level the load of solids that are passed to the water treatment vessels. The disadvantage of both the semi-continuous and periodic methods is that solids are still allowed to settle in the bottom of the vessel where they can
15 only be partially removed by each subsequent periodic washing.

While either method can handle the volume of fines in a refinery desalter, there remains a more significant problem that has not been properly dealt with before. This problem is the solid-laden rag that hangs at the oil-water interface. Once this interface mud accumulates at the interface it becomes quiescent and the rate of water and solids
20 separation is slowed significantly. When the rate of collapse for interface rag is slower than the rate of accumulation, the interface volume increases and interferes with the desalter operation. While the exact nature of this interface rag cannot be readily determined, the effects are detrimental to the performance of the desalter in one of two ways.

If the interface rag floats on top of the water, then it can grow in height until it interferes with the integrity of the electrostatic field by increasing the current demand and reducing the field strength. The electric field does apply added energy to the top of the interface and can accelerate the rate of decay. If the interface sinks into the water layer it rapidly occupies the water volume of the desalter and reduces the water residence time. The effect is a decline in the water quality that is passed to the water treatment facility as the interface rag settles to the bottom of the vessel to form mud and mixes with the brine exiting to the brine heat exchangers and benzene recovery unit. This mixing accelerates the fouling and plugging of the heat exchangers and benzene recovery unit.

Because refineries have more complex and overlapping issues, system applications need to be expanded beyond the simple purpose of removing sludge and solids from the bottom of desalter vessels. A need exists, therefore, for a system that assists a refinery in meeting planned crude unit run-length expectations, does not put the desalter in an upset condition during operation, minimizes or eliminates sludge buildup at the bottom of the vessel, improves basic sediment and water (BS&W) reduction performance, improves salt reduction performance, minimizes emulsion and reverse emulsion buildup at the oil/water interface, keeps solids suspended in the brine until the solids exit to the process sewer, and protects process equipment ahead of the waste water treatment plant.

BRIEF SUMMARY OF THE INVENTION

A method and system for controlling an interface rag layer within a desalter vessel includes injecting a water flow through a plurality of nozzles arranged about a piping circuit so that a volume of water in the brine water layer rotates, thereby
5 uniformly suspending solids in the brine water and promoting a collapse of the interface rag layer from the brine water side of the rag layer. The piping circuit is preferably located in an upper portion of the water layer—preferably in the upper two-thirds of the water layer—and an external periphery of the piping circuit lies near to and opposite of an internal periphery of the desalter vessel.

10 Each nozzle in the plurality of nozzles lies in the same horizontal plane and is oriented toward an interior space of the desalter vessel at the same angular orientation as all other nozzles. Water flow through the nozzles, which may be in a range of 1 to 3 fpm, promotes a slow and continuous agitation of the water. The interface rag layer may be monitored and the water flow adjusted accordingly. Each nozzle may be a drilled
15 passageway and is preferably oriented in the horizontal plane at an angle of about 15° to 60° relative to a pipe circuit center line and at a downward angle of about 15° to 60° from the horizontal plane. The rotation of the water, therefore, is coincident to the angular orientation of the nozzle in the horizontal plane, either clockwise or counterclockwise, and forms a toroidal rotation coincident to the downward angular
20 orientation of the nozzles that gently sweeps both the bottom of the rag layer and the bottom of the vessel.

A better understanding of the method and system for controlling the interface rag layer will be obtained from the following detailed description of the preferred embodiments taken in conjunction with the drawings and the attached claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view of a prior art desalter equipped with a mud washing system. The washing system consists of a set of spray nozzles that disperse a volume of fresh water into the desalter for the purpose of agitating the mud that has settled at the bottom of the vessel so that the mud can be effectively removed from the desalter through a series of mud drains located at the bottom of the desalter. This system does not address the solid-laden rag that collects and hangs at the lower surface of the oil-water interface layer.

FIG. 1A is a view of a preferred embodiment of a desalter equipped with a wash system made according to this invention. Two piping circuits are equipped with a series of nozzles and independently controlled. The first piping circuit, which is placed below the interface rag layer, includes a set of nozzles oriented to gently scrub the bottom of the interface rag and promote separation. The second piping circuit, which is placed above the mud layer, includes a set of nozzles oriented oblique to the mud layer to gently fluidize the mud from the bottom of the vessel.

FIG. 2 is a view of another preferred embodiment of a desalter equipped with a wash system made according to this invention. The wash system includes a piping circuit that is equipped with a series of nozzles oriented at an angle in the horizontal plane and also at a downward angle in the vertical plane. Water from the water layer is recycled into the piping circuit and re-injected into the water layer at a low flow rate.

FIG. 3 is a top view of the wash system of FIG. 2 and illustrates the spacing relationship between the oblong-shaped piping circuit and the interior wall of the desalter. The piping circuit is preferably laid across horizontal supports as illustrated and clamped in place.

FIG. 4 illustrates the turbulence of the water layer caused by the nozzles of the piping circuit of FIG. 2. Once the flow from the nozzles is established, the bulk of the

water layer will begin to rotate slowly in a toroidal-shaped rotation in the vertical plane and in the horizontal plane. These combined rotations prevent the build-up of mud by lifting the fines from the bottom of the desalter and continuously agitating the lower surface of the interface rag layer.

5 FIG. 4A illustrates the flow pattern of FIG. 4 in greater detail. The flow pattern is a rotating plane toroidal flow that consumes each sector and looks like a series of large horizontal plane doughnuts.

FIG. 5 is a vertical cross-sectional view taken along the line 5-5 of FIG. 2.

FIG. 6 is a vertical cross-sectional view taken along section line 6-6 of FIG. 1A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention provides a method and system for preventing mud build-up within a separator vessel by continuously agitating the lower surface of the interface rag layer so as to suspend solids in the water layer and promote the collapse of mud residing in the interface rag layer. Elements illustrated in the drawings are identified by the following numbers:

10	Interface emulsion control system	56	Water layer
20	Separator vessel	58	Oil-coated solids/mud
22	Upper portion of 20	60	First piping circuit
24	Lower portion of 20	62	Nozzle
26	Oil outlet	64	Outer periphery of 60
28	Top of 20	66	Inner periphery of 60
30	Water outlet	68	Centerline of 60
32	Bottom of 20	70	Recycle pump
34	Rag drain	72	Recycle piping
36	Inner wall surface of 20	80	Mud wash system
38	Recycle pump	82	Piping
40	Recycle piping	84	Spray nozzle
42	Interface rag	86	Mud drain
50	Oil layer	88	Second piping circuit
52	Interface emulsion layer	90	Supports
54	Lower surface of 52	92	Nozzle

Referring first to FIG. 1, a separator vessel 20 is connected by conventional piping (not shown) to a crude oil source. Vessel 20 is of a type well-known in the art and commonly used in crude oil production and refining for dehydration and desalting of crude oil. A crude oil stream containing water and solid contaminants enters vessel 20 through the identified "oil inlet". Vessel 20 typically holds those components and processes them so that the oil is separated from the contaminants. The separated oil layer 50 is then removed from vessel 20 through an outlet 26 located at the top 28 of vessel 20.

During the separation process, it is common for oil-coated solids, called mud 58, to accumulate on a bottom 32 of vessel 20 and for a layer comprising a mixture of oil and water, called interface emulsion layer 52, to form in an intermediate portion of vessel 20. A solid-laden or brine water layer 56 accumulates between the layer of mud 58 residing on the bottom 32 and the layer of interface rag or emulsion 52. To prevent the interface rag layer or emulsion 52 from accumulating until its presence begins to interfere with the performance of vessel 20, a rag drain 34 may be provided (See FIG. 2). The removal of the interface rag layer or emulsion 52 preferably occurs continuously and the removal rate may vary over time. Oil layer 50 accumulates above the interface emulsion layer 52 in the upper portion 22 of vessel 20.

Some "rag," referred to as interface rag 42, rather than settling to the bottom 32 of vessel 20, may float on top of the water layer 56 and "hang" at the lower surface 54 of the interface emulsion layer 52 as shown in FIG. 1. As this interface mud 42 accumulates it becomes quiescent and the rate of water and solids separation is slowed significantly. When the rate of collapse and settlement of interface rag 42 is slower than the rate of its accumulation, the volume of interface emulsion layer 52 increases and begins to interfere with the operation of vessel 20. For example, interface rag 42 may sink into the water layer 56 and occupy water volume, thereby reducing water residence time, decreasing the quality of water passed to a treatment facility. Additionally, interface emulsion layer 52 may grow in height until it interferes with the integrity of an electrostatic field (not shown in the drawings) being applied to promote separation of components in the crude oil. Furthermore, as the interface rag 42 collapses it settles to the bottom 32 of vessel 20 and contributes to oil coated solids/mud 58 that accumulates in the vessel bottom. This oil-coated solids/mud 58 must be removed periodically, usually by way of a prior-art mud wash system 80 (see FIG. 1).

A mud wash system 80, as known in the prior art, includes piping 82 arranged in sections along a lower portion 24 of vessel 20 at a distance " h_1 " from the bottom 32 of vessel 20 (usually in the bottom third of water layer 56). Piping 82 may include two outer pipes (not shown) that run near and along the interior wall surface 36 of vessel 20 and one middle pipe (not shown) spaced equidistant from, and running parallel to, each outer pipe. A series of spray nozzles 84 are connected to the piping 82 and oriented downward at a 90° angle relative to a centerline line of piping 82. The spray nozzles 84 disperse a volume of water into the desalter for the purpose of agitating the mud 58 so it can be effectively removed from the desalter by way of mud drains 86. A recycle pump 70 and recycle piping 72 may be employed to recycle the mud wash water.

Prior-art mud wash system 80 does not prevent the build-up of mud 58. This system also does not prevent episodic build-up of the interface emulsion layer 52, nor does it reduce salt, reduce basic sediment and water (BS&W), eliminate interface rag 42, or eliminate reverse emulsion migration from interface emulsion layer 52 to water layer 56.

Referring to FIGS. 2–5, a system 10 is illustrated for slowly and continuously agitating the interface emulsion layer 52 to prevent or control the build-up of interface emulsion layer 58 and keep the fines that contribute to mud layer 42 suspended in the brine water layer 56. System 10 (to be described) imparts enough velocity and motion into the water layer 56 to suspend solids therein until they are removed with water layer 56 as it is removed from vessel 20 and also creates a washing action under interface rag 42 to aid in water-wetting solids and recovery of oil to oil layer 50. System 10, which is capable of servicing desalter operations across a full range of API gravity crude oils, preferably utilizes no filters.

System 10 includes an oblong-shaped first piping circuit 60 that is located in a lower portion 24 of vessel 20. The outer peripheral surface 64 of first piping circuit 60 is at distance “d” from the inner wall surface 36 of vessel 20. The piping circuit 60 is also at a distance “h₂” from the bottom 32 of vessel 20. In a preferred embodiment, distance
5 h₂ places first piping circuit 60 in the upper two-thirds of the height of water layer 56 in vessel 20. First piping circuit 60 may be supported by a set of horizontal supports 90 as seen in FIG. 3.

First piping circuit 60 produces a slow circulation of water layer 56 and, therefore, a slight water velocity across the lower surface 54 of the interface emulsion
10 layer 52. This slight velocity, which is established by a series of angled nozzles 62, prevents build-up of interface rag 42 and reduces or eliminates mud 58. Furthermore, the continuous circulation helps keep fines suspended in water layer 56 so that the fines are discharged directly with the discharge of water layer 56, thus eliminating the need for frequent mud wash of vessel 20.

15 Nozzles 62 are arranged and spaced about the inner periphery 66 of first piping circuit 60 (see FIG. 3) and generally are pointed interiorly of vessel 20. Nozzles 62 may be drilled passageways in first piping circuit 60 or may be, as illustrated, short length tubular members. Each nozzle 62 is preferably oriented at an angle of between about 15° and 60° in a horizontal plane relative to a line perpendicular to centerline 68 of first
20 piping circuit 60 and at a downward angle of between about 15° and 60° in the vertical plane. The 15° to 60° angle translates to a 30° to 75° angle between a line drawn through the longitudinal centerline of the nozzle 62 and a line drawn perpendicular to centerline 68. The preferred horizontal and vertical plane angle is 45°. Alternatively, each nozzle 62 may be oriented at between about 105° and 150° in the horizontal plane,
25 thereby promoting a clockwise (opposite) flow.

Referring to FIGS. 4 & 4A, the water flow through each nozzle 62 is preferably at a low flow rate in the range of about 1 to 3 feet per minute (fpm). Once the flow from the nozzles 62 is established, the bulk of water layer 56 will begin to rotate slowly and in two directions, R_1 and R_2 . Rotation R_1 is in a horizontal plane coincident to the clockwise or counterclockwise orientation of nozzles 62. Rotation R_2 is a toroidal-shaped rotation in a vertical plane. Rotations R_1 and R_2 continuously agitate the lower surface 54 of the interface emulsion layer 52 and keep the solids suspended in water layer 56 by lifting the fines from the bottom 32 of vessel 20. The flow pattern created by R_1 and R_2 is substantially a rotating plane toroidal flow that consumes each sector S and looks like a series of large horizontal plane doughnut-shaped flows (see FIG. 4A).

Controls (not shown) may be provided to control the water flow through nozzles 62, with first piping circuit 60 being controlled independent of second piping circuit 88. The flow may be adjusted, for example, to bring the level or volume of the interface emulsion layer 52 within a predetermined range.

Water removed from vessel 20 through water outlet 30 may be routed to a recycling pump 38 for recycling the water back into the water layer 56. Recycling pump 38 is preferably an ANSI/API centrifugal pump including duplex seals with barrier fluid and an expeller on the back of the impeller to protect seal integrity. No filtration is required in the recycle piping 40.

In a preferred embodiment, after the initial lineout of desalter operation, the water flow rate through nozzles 62 is increased until interface rag layer 52 begins to upset. The water flow rate is then reduced until interface emulsion layer 52 begins to stabilize. Interface rag layer 52 is then monitored at the first tryline under the interface emulsion layer 52 and appropriate adjustments made to the water flow rate.

Referring now to FIGS. 1A & 6, an alternate embodiment of system 10 includes an oblong-shaped first piping circuit 60 and an oblong-shaped second piping circuit 88, each equipped with nozzles 62, 92 and independently controlled. The water flow through each nozzle 62, 92 is preferably at a low flow rate in the range of about 1 to 3 feet per minute (fpm). First piping circuit 60 is placed below the interface emulsion layer 52 at a distance " h_3 " from the bottom 32 of vessel 20 in order to gently scrub the bottom of the interface emulsion layer 52. Nozzles 62 are preferably oriented at an angle of between about 15° and 60° in a horizontal plane and in a vertical plane relative to centerline 68 of first piping circuit 60 (see FIGS. 2 & 3).

Second piping circuit 88 is placed at a distance " h_1 " from the bottom 32 of vessel 20 in order to gently fluidize the mud 58 from the bottom 32 of the vessel 20. Unlike the arrangement of the prior art mud wash system 80 and its nozzles 84 (see FIG. 1), second piping circuit 88 is an oblong-shaped circuit similar to that of first piping circuit 60, with its nozzles 92 oriented oblique to the mud layer 58. Nozzles 92 are preferably oriented at an angle of between about 15° and 60° in the horizontal plane relative to the centerline of second piping circuit 88 and at a downward angle of between 15° and 60° in the vertical plane. Preferably, there is no interference between the upper and lower toroids.

A system 10 made according to this invention affects a number of performance issues typically associated with a separator vessel 20. System 10 eliminates or minimizes episodic build-up of the interface emulsion layer 52, reduces salt, reduces basic sediment and water (BS&W), eliminates rag layer separation, and eliminates reverse emulsion migration from the interface rag to the brine water layer.

While preferred embodiments of an interface and mud control system have been described with a certain degree of particularity, many changes may be made in the details of construction and the arrangement of components without departing from the spirit and

scope of this disclosure. The control method and system therefore is not limited to the embodiments set forth herein for purposes of exemplification, but are to be limited only by the scope of the attached claims, including the full range of equivalency to which each element or step thereof is entitled.

WHAT IS CLAIMED IS:

1. A system for controlling an interface emulsion layer and a volume of mud forming within a desalter vessel, the system comprising:
 - at least one piping circuit having a plurality of nozzles and being located in a
 - 5 brine water layer residing within the desalter vessel;
 - each nozzle in said plurality of nozzles being oriented toward an interior portion of said desalter vessel at an oblique angle in at least one of a horizontal plane and a vertical plane relative to a center line of said piping circuit.
- 10 2. A system according to Claim 1 wherein the orientation of said plurality of nozzles is effective for creating a horizontal and vertical rotation of the brine water layer to agitate a lower surface of an interface emulsion layer residing between the brine water layer and an oil layer.
- 15 3. A system according to Claim 1 wherein said oblique angle is between about 15° and 60° for each nozzle lying on a straight-run portion of said at least one piping circuit.
4. A system according to Claim 3 wherein said oblique angle is about 45°.
- 20 5. A system according to Claim 1 further comprising a means for recycling a volume of the brine water layer to the at least one piping circuit.
6. A system according to Claim 1 further comprising each nozzle being a nozzle selected from the group consisting of a drilled passageway and a short tubular member.

7. A system according to Claim 1 further comprising an external periphery of said piping circuit lying near to and opposite an internal periphery of said desalter vessel.
8. A system according to Claim 1 wherein a water velocity through each nozzle is in
5 a range of 1 to 3 fpm.
9. A system according to Claim 1 wherein at least one piping circuit is located in a horizontal plane situated in an upper two-thirds portion of the brine water layer.
- 10 10. A method for controlling an interface emulsion layer and a volume of mud forming within a desalter vessel using the system of Claim 1.