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**METHOD FOR CLEANING AN OIL STORAGE TANK AND DEVICE FOR
IMPLEMENTING SAME**

This invention relates to a method for cleaning an oil storage tank with a floating roof containing crude oil and a device for implementing said method.

It is known that crude oil storage tanks are very frequently cylindrical tanks with a floating roof. Therefore, the roof structure is at a variable height above the ground, depending on the quantity of crude oil located in the tank. Obviously, there are sealing devices around the periphery of the floating roof to prevent oil from escaping around the periphery of the roof. It has been found that in these storage tanks, a sediment composed largely of the heaviest fractions of the stored crude oil, and particularly paraffin compounds and inorganic elements such as water, sand, rust or similar particles, are gradually deposited on the bottom of the tank. This sediment is called sludge and can form very thick layers one or two meters thick or more on the bottom of the tank, and the tanks have to be cleaned by removing this sediment. If the sediment accumulates at the bottom of the tank, and the floating roof goes down

as the tank is emptied, there is a risk of the floating roof coming into contact with the deposited sediment at a particular point, which unbalances the roof, possibly blocking it in an inclined position against the shell of the tank; since the floating roof can weigh several hundred tons, it is easily seen that the cost of repairing this type of incident can be very high.

In order to enable the tank to be completely emptied without the floating roof coming into contact with the bottom of the tank, sleeves are provided in the floating roof, and support props are inserted in the sleeves. When the roof moves downwards towards the bottom, all support props are simultaneously supported on the bottom, which keeps the roof at a distance above the bottom so that the crude oil contained in the tank can be completely emptied from it. One method that has already been proposed to extract the sediment after all liquid oil has been removed from the tank, is for a person to enter into the tank through the manholes at the bottom of its shell and remove it manually. This operation is long, unpleasant and expensive and the sediment thus removed from the tank must be taken away without causing any pollution; it is then usually destroyed by incineration. The global cost of this cleaning operation is prohibitive.

Another proposed method is to insert a central stirrer through a manhole when the tank is empty, and to place it close to the sediment layer and rotate it around a vertical axis; this type of stirrer uses the thixotropic nature of the sediment to attempt to put it in suspension when liquid oil is added into the tank, but it only has a local influence within the central part near the bottom of the tank, and furthermore the power necessary to rotate it at an efficient speed creates an

emulsion composed of water in the sediment and the crude oil, and this emulsion is highly undesirable for use of the stored crude oil. Therefore, this type of cleaning device is not satisfactory.

Another proposed method is to place helical stirrers uniformly distributed around the periphery of the tank, near the bottom of the shells; these helical stirrers effectively create a movement of the sediment from the tank periphery towards the central area of the said tank, but the global volume of the sediment layer is not significantly reduced; on the other hand, the thickness of the sediment layer becomes much more irregular such that the risk of an incident occurring when the roof is being lowered is very real. Finally, the use of this type of helical stirrer is extremely expensive, considering the necessary energy necessary to drive them. Therefore this type of process is not satisfactory.

US 4,828,625 describes an apparatus and method for removal of sludge from a tank having a floating roof floating on the upper surface of oil within the tank. Discharge nozzles are received within existing sleeves on the floating roof and positioned adjacent the upper surface of the sludge for the recirculation of the contents of tank directly into the sludge from a position above the sludge. A recirculation pump provides pressurized fluid to a manifold on roof for distribution through flexible lines to the discharge nozzles.

US 5,087,294 describes a method and device are provided for cleaning a storage tank for petroleum products of the type having a closed sidewall and a floating roof which floats upon the top of the petroleum products.

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Additionally, a plurality of downwardly depending legs are removably secured to the floating roof which engage the bottom of the storage tank when it is nearly empty thereby preventing the floating roof from contacting the bottom of the storage tank. The device includes an elongated nozzle having an upper end and a lower end with at least two spray jets adjacent its lower end. One of the legs is removed from the floating roof of the storage tank thereby forming an opening into which the nozzle is inserted so that its lower end is positioned adjacent the bottom of the storage tank. Thereafter, petroleum products under high pressure are pumped through the nozzle and thus through the spray jets. In doing so, the spray jets emulsify dirt, waxes, and other petroleum distillates which accumulate at the bottom of the tank. The above process is repeated for a number of spaced openings along the floating roof of the storage tank.

The invention is based on the fact that the sediment can be put back into suspension in the overlying crude oil, provided that swirl and/or vortices can be generated throughout the entire volume of crude oil above the sediment, and sufficiently powerful oil jets can be directed onto the sediment to gradually bring it back into suspension and then keep it in this state by the imposed swirl in the liquid crude oil. In this way, the sediment layer gradually disappears into the liquid crude oil, such that the sediment can be used since there is no longer any sedimentary material to be taken out of the tank to be destroyed. Therefore, according to the invention, the sediment in the tank is partially drained so that a restricted quantity of crude oil is left above the sediment, and swirl or vortices will be created in the entire volume of this restricted quantity firstly by sucking in liquid at a level lower than the level of the

liquid crude oil, and secondly by reinjection of the pumped liquid crude oil into the tank, the drawn out and reinjected flow being sufficiently high compared with the total remaining volume under the floating roof at the time of the cleaning operation. Reinjection into the tank takes place through rotating lances located vertically under the floating roof, these lances being equipped with nozzles that direct oil jets towards the sediment layer; rotation of the lances creates vortices along the center line of the lances, such that these vortices affect the entire tank. This is done by replacing the props under the floating roof by lances that reinject crude oil, the bottom of the lances arriving close to the median plane of the top surface of the sediment layer.

One consequence of this invention is a process for re-suspension of a sediment which was deposited to form a layer on the bottom of a tank with floating roof containing crude oil, the said floating roof comprising a plurality of holes for props uniformly distributed around its surface, the said holes being used to fix the roof support props to the roof, these props transferring the weight of the roof to the bottom of the tank when the depth of crude oil in the tank is less than the length of the props, characterized by the fact that:

- the crude oil level in the tank is adjusted until it is a distance L above the highest level of the sediment on the bottom of the tank, where L is between about 2 and 5 meters,
- the crude oil is sucked out of the tank by at least one pump with a global hourly flow equal to V/n , where V is the volume remaining in the tank below the floating roof and n is a number between about 8 and 15,

- the pumped crude oil is reinjected into the tank using lances fixed to the floating roof and placed vertically in the tank above the sediment, the length of each of the said lances below the floating roof being less than L , each of the lances being driven in rotation around its center line, closed off at its lower end and fitted with at least one nozzle located above the sediment, the jet of the nozzle being directed towards the bottom of the tank, the output cross-section of the nozzle(s) on any one lance being small enough so that the output pressure from the crude oil jet, at the discharge flow from the pump(s), is high enough for the swirling volume generated by a lance to intersect the swirling volumes created by the adjacent lances,
- the process is continued until the density of the pumped crude oil is equal to a predetermined value corresponding to the sediment being almost entirely put back into suspension.

The choice of the number n that defines the global drawn in hourly flow reinjected into the tank depends on the characteristics of the tank to be cleaned by putting the sediment back into suspension, the physicochemical characteristics of the sediment itself and the acceptable time during which the tank can be taken out of service for cleaning.

According to one preferred embodiment of the process according to the invention, there are several nozzles distributed along the length of each lance, such that the swirling volume generated by the lance affects the full height of the layer of liquid crude oil remaining in the tank. Preferably, the lances are rotated at a speed of between 0.25 and 4 revolutions per minute. The lances

may be rotated around their center lines by explosion proof electric motors, with one motor being assigned to each lance.

Another purpose of the invention is a device for use of the process as defined above, this device being characterized by the fact that the lances are placed in sleeves through prop holes in the tank floating roof. The installation of rotary lances in the prop holes, in other words in the sleeves that normally hold the props rigidly attached to the floating roof, has the main advantage that the cleaning device according to the invention can be put into position without making any modifications to the floating roof of the tank to be cleaned; all that is necessary is to remove the props one by one and to gradually replace them by rotary lances. Since the prop holes are sufficiently close together, the rotary jets output from these lances stir the entire volume of crude oil remaining in the tank, thus causing erosion of sediment fragments until all fragments are completely put back into suspension.

According to one preferred embodiment of the device according to the invention, each lance is fitted with a plurality of nozzles located at different levels above the bottom of the tank, the jets from nozzles at the lower level being directed towards the bottom of the tank, whereas the jets from nozzles at the higher level are directed towards the floating roof; advantageously, each lance is fitted with three nozzle levels, a nozzle at the median level generating an approximately horizontal jet, whereas the nozzles at the two other levels generate jets at an axis inclined by 50 to 70° from the center line of the lance on which the nozzle is supported. It would be possible for each nozzle level to be fitted with two diametrically opposite nozzles.

Preferably the level of the lowest nozzle(s) is between 20 and 50 cm above the average level of the sediment layer.

Advantageously, one or more volumetric pumps may be used to draw crude oil from the tank; for example, screw pumps could be used. This type of pump produces a given output and pressure obtained at the nozzle output, and consequently depends on the cross-section of all nozzles supplied by the pump. The volume affected by the swirl created around a nozzle obviously increases with increasing jet output pressure. Steps are taken to ensure that these volumes, that are approximately cylindrical centered around the center line of the lances, intersect with the corresponding volumes created by adjacent lances so that none of the crude oil contained in the tank is unaffected by the general turbulence created according to the invention.

Obviously, mixing of the sediment also entrains resuspension of inorganic elements contained in the sediment. Therefore, a pump intake filter is provided to eliminate these inorganic elements, and in any case all parts that pass through the filter will be ground by the pump screws. When the cleaning operation according to the invention is terminated, there is a filtered homogeneous liquid in the tank consisting of crude oil available to be transferred directly to the tanker, and secondly a very thin layer on the bottom of the tank composed of the heaviest solid inorganic particles initially contained in the sediment. Usually, the tank operator empties the liquid contained in the tank by transferring it to another tank containing a similar crude oil, obviously after having put the floating roof props into position instead of the lances used for implementation of the process according to the invention.

After the crude oil has been mixed with the contents of another tank, the crude oil used for cleaning according to the invention can be refined.

According to a preferred embodiment, the device according to the invention comprises at least two pumps each preceded by at least one filter and each followed by a distributor, each output channel from the distributor leading to a containment that supplies p lances, where p is the same integer number for all containments used in the device.

We will now describe a purely illustrative example of a non-restrictive embodiment shown in the attached drawing to facilitate understanding of the purpose of the invention.

On this drawing:

- figure 1 diagrammatically shows a device for use of the process according to the invention,
- figure 2 diagrammatically shows a sectional view through a crude oil tank with floating roof in which a lance has been inserted for reinjection of pumped crude oil as shown in figure 1, the other lances not being shown,
- figure 3 shows a plane view of the tank floating roof according to figure 2, this view showing the prop sleeves provided on the said floating roof, and the circles delimiting the cylindrical swirling volumes generated by each of the lances inserted in the said prop sleeves being shown as dotted lines.

With reference to the drawing, it can be seen that the complete crude oil storage tank is denoted as 1; the tank 1 is composed of a cylindrical shell 1a, the base 1b of which forms the bottom of the tank. The tank is equipped with a floating roof 2, the periphery of which

comprises sealing devices not shown. The tank 1 is designed for the storage of crude oil, while the roof 2 floats on the crude oil. Conventionally, the diameter of this type of tank may be about 50 m and its height may be 15 m. In this type of tank, the crude oil gradually settles to the bottom of the tank 1b to form a sediment 3 that can be several meters thick; the surface of the layer is relatively irregular. The sediment is usually thixotropic.

In order to clean a tank of this type and to remove the sediment layer 3, the tank is partially emptied; if it is assumed that the average thickness of the sediment layer is 1 m, about 3 m of crude oil is allowed to remain in the tank above the sediment, in other words the roof 2 will be about 4 m above the bottom of the tank. In the example described, the floating roof 2 is fitted with 72 props that pass through the roof through prop sleeves shown as reference 4 in figure 3. The length of these props is between 1.8 and 2.2 m, and they are supported on the bottom of the tank when the floating roof becomes sufficiently low.

When the floating roof 2 is lowered to 4 m above the bottom of the tank, the props are removed one by one and are replaced by lances 5; each lance 5 is a tube that is put into place free to pivot in a prop sleeve. The lance 5 is driven in rotation about its center line by an explosion proof electric motor 6 fitted at the top of the lance above the floating roof 2. The crude oil supply to lance 5 passes through a pipe 7. The lance 5 is fitted with three levels of nozzles that discharge the crude oil transported through pipe 7 into the tube from which the lance is made. These nozzles control the direction of the discharge jets. Each level is fitted with two diametrically opposite nozzles on the lance. The two

lower level nozzles supply jets 8a for which the axes make an angle of 60° with the center line of the lance 5, these jets being directed towards the bottom of the tank; the two top nozzles provide jets 8c for which the axes make an angle of about 60° with the axis of lance 5, these jets being directed towards the floating roof 2; the two middle nozzles form jets 8b from which the axes are approximately horizontal. The level of the lower nozzles is about 30 cm above the level of the average level of the layer of the sediment 3; the level of the middle nozzles is about 60 cm above the bottom nozzles and the level of the top nozzles is about 60 cm above the middle nozzles. The bottom of lances 5 is closed off. The motors 6 drive the lances 5 at two revolutions/minute.

Pumping in tank 1 is done by two pumps 8; the pumps 8 are volumetric screw pumps with a capacity of 400 m³/h each. Pumps 8 are installed in parallel and a filter 9 is placed on the inlet side of each pump. The two filters 9 are connected to the output from a 2000-liter tank 10, the input of which is connected through a pipe 11 to the lower part of the shell 1a of tank 1. Filters 9 are provided to eliminate inorganic elements in the pumped oil. Each of the two pumps 8 outputs to a distributor 12. Each distributor 12 is provided with three outputs, and each output discharges into a 200-liter containment 13; each containment 13 is fitted with six outputs fitted with a valve 14, and each connected to a pipe 7 to supply two lances 5.

When the pumps 8 draw in crude oil in tank 1 and discharge it into lances 5, a turbulent and swirling volume is created around each lance delimited approximately by the circles shown in dashed lines in figure 3. The output cross sections of the nozzles are

chosen to be low enough so that the jet ejection pressure is high enough for the radius of the swirling volume created around the lance to intersect the swirling volumes corresponding to adjacent lances. In this way, all the liquid crude oil above the sediment is put into movement. The bottom nozzles of lances 5 create rotating jets that attack the upper surface of the sediment 3, which is thixotropic and consequently goes back into suspension in the crude oil above it. Since this crude oil is mixed throughout its volume, the sediment cannot be redeposited and becomes distributed throughout the entire volume of crude oil above the sediment layer 3.

After operation for between 5 and 7 days, it is found that almost the entire sediment has disappeared from the bottom surface of the tank 1b, and all that remains on the said bottom is inorganic elements initially contained in the sediment. The end of the operation is usually decided upon by measuring the density of the crude oil, and cleaning is stopped when the density reaches a value determined in advance by calculations using initial crude oil samples and the relative volumes of the sediment and the crude oil kept in the tank for the cleaning operation.

CLAIMS

1. Process for re-suspension of a sediment (3) which was deposited to form a layer on the bottom of a tank (1) with floating roof (2) containing crude oil, the said floating roof (2) comprising a plurality of holes for props (4) uniformly distributed around its surface, the said holes (4) being used to fix the props to the roof (2) to support the roof (2), these props transferring the weight of the roof (2) to the bottom of the tank (1b) when the depth of crude oil in the tank (1) is less than the length (D) of the props, wherein:

- the crude oil level in the tank (1) is adjusted until it is a distance (L) above the highest level of the sediment (3) on the bottom of the tank (1b),
- the crude oil (1) is sucked out of the tank by at least one pump (8) with a global hourly flow equal to V/n , where V is the volume remaining in the tank (1) below the floating roof (2),
- the pumped crude oil is reinjected into the tank (1) using lances (5) fixed to the floating roof (2) and placed vertically in the tank (1) above the sediment (3), the length of each of the said lances (5) below the floating roof (2) being less than L , each of the lances being driven in rotation around its center line, closed off at its lower end and fitted with at least one nozzle located above the sediment (3), the jet (8a) of the nozzle being directed towards the bottom of the tank (1a), the output cross-section of the nozzle(s) on any one lance (5) being small enough so that the output pressure from the crude oil jet at the discharge flow from

the pump(s) (8) is high enough for the swirling volume generated by a lance (5) to intersect the swirling volumes created by the adjacent lances (5),

- the process is continued until the density of the pumped crude oil is equal to a predetermined value corresponding to the sediment (3) being almost entirely put back into suspension, characterized by the fact that the distance L is chosen to be between about 2 and 5 meters, the number n between about 8 and 15 and the lances (5) are rotated at a speed between 0.25 and 4 revolutions/minute,

characterized by the level of the bottom nozzle(s) at between 20 and 50 cm above the average level of the sediment layer (3); a plurality of nozzles in each lance (5) located at different levels above the bottom of the tank (1b), the jets (8a) of the bottom nozzles being directed towards the bottom of the tank (1b) whereas the jets (8c) from the top nozzles are directed towards the floating roof (2); each lance (5) comprises three levels of nozzles, one middle nozzle generating an approximately horizontal jet (8b) whereas the nozzles on the other two levels generate jets (8a, 8c) with a center line inclined at 50 to 70° from the center line of the lance (5) that supports the nozzle.

2. Process according to claim 1, characterized by the fact that a plurality of nozzles is distributed along the length of each lance (5), such that the swirling volume generated by one lance (5) affects the entire depth of the layer of liquid crude oil remaining in the tank (1).