

Description

CRUDE OIL PROCESSING APPARATUS AND CRUDE OIL PROCESSING METHOD

Technical Field

[0001] The present invention relates to a crude oil processing apparatus and a crude oil processing method for processing crude oil including crude oil sludge.

Background Art

[0002] On a bottom portion of a tank storing crude oil, such as a tank for crude oil produced from a crude oil well, a tank in a refinery or a tank in a stockpiling base, crude oil sludge in a semi-solid state accumulates. Since problems in operation management occur if too much crude oil sludge accumulates in the tank, and a periodic inspection in the tank is necessary, it is a common practice to discharge the accumulated crude sludge out of the tank (de-sludging) at a predetermined cycle. Opening of the tank and discharge of the crude oil sludge are big problems for an owner of the tank, such as a large cost, long-term work, and, furthermore, security of safety during the work and prevention of environmental pollution due to leakage of crude oil or crude oil sludge. Further, crude oil sludge includes a lot of oil (30 to 80%), and it is strongly desired to not only merely discharge crude oil sludge from a tank but also recover as much oil from the crude oil sludge as possible, not only for the purpose of reducing an amount of waste but also from an economic point of view (for example, see Patent Literature 1).

[0003] There are several methods for recovering oil from crude oil sludge. A method most widely performed is a method called a COW (crude oil washing) method in which a solvent such as crude oil or light oil is jetted to crude oil sludge to dissolve the crude oil sludge, and the crude oil sludge is mixed with the crude oil and transferred to another tank. Specifically, the COW method is a method in which by heating and voltage-boosting crude oil in a tank (A), jetting the crude oil to crude oil sludge in a tank (B) in which the crude oil sludge has accumulated, mixing the crude oil sludge dissolved by jetting of the crude oil with the crude oil and transferring the mixture into the tank (A), the crude oil sludge in the tank (B) is removed. By using the COW method, work performed by a person entering a tank and discharging crude oil sludge out of the tank using appliances becomes unnecessary, and, therefore, processing of crude oil sludge can be improved from a view point of a cost, a work period, and safety and environmental protection (HSE: health, safety and environment).

Further, as another method, a method is known in which crude oil sludge discharged from a tank is separated into oil, moisture and solids by a centrifuge, and only the oil is recovered. By using a centrifuge, it is possible to separate oil and other impurities (unnecessary components), and, therefore, it is possible to appropriately recover only oil from crude oil sludge.

Document List

Patent Literature

[0004]

Patent Literature 1: Japanese Patent Application Publication No. 2012-229403

Summary of Invention

Technical Problem

[0005] In the COW method, however, unnecessary components such as moisture and solids in crude oil sludge are also transferred into a tank together with crude oil, and quality of the crude oil deteriorates. Therefore, especially in a place where it is required to clear strict quality standards (for example, BS&W (basic sediment & water) which is one of quality management items < 0.5 vol%) like a tank of an oil producing country, there is a strong possibility that a quality problem is caused in crude oil as a product. Furthermore, most of crude oil sludge components transferred together with the crude oil reprecipitate in the tank with elapse of time. Therefore, as a result, only a tank in which crude oil sludge accumulates is changed, and recovery of oil included in the crude oil sludge is not sufficient.

Though the method using a centrifuge is relatively superior in recovery of oil included in crude oil sludge, it cannot be said that recovery of oil from solids is sufficient. Processing speed is limited, and a work period is prolonged. Further, if a plurality of centrifuges are installed to increase an amount of processing, a huge cost is incurred. Further, at the time of discharging crude oil sludge from a tank to guide the crude oil sludge to a centrifuge, a person is forced to perform work under an environment unfavorable to the person of entering a tank and discharging crude oil sludge by appliances or a heavy machine as done conventionally. Furthermore, a cost for accessory equipment for preparing an environment for operation of the centrifuge is incurred.

In any of the above methods, it is necessary to stop operation of a tank for a long time at the time of performing work for removing crude oil sludge in the tank.

[0006] The present invention has been made in view of the above problem, and it is an object of the present invention to provide a crude oil processing

apparatus and a crude oil processing method for decreasing accumulated crude oil sludge without stopping operation of a crude oil tank and performing processing to efficiently recover a lot of oil while improving various problems that occur at the time of discharging crude oil sludge from inside a tank.

Solution to Problem

[0007] In order to solve the above problems, the present invention is a crude oil processing apparatus characterized by including: a tank for storing crude oil including crude oil sludge; and a processing portion for applying a voltage to the crude oil supplied from the tank to generate an electrostatic field region to process the crude oil.

[0008] Further, it is preferred that a sludge stirring portion for stirring the crude oil sludge accumulating in the tank is provided, and the processing portion processes the crude oil stirred by the sludge stirring portion.

[0009] Further, it is preferred that a water adding portion for adding water to the crude oil and a water stirring portion for stirring the water added by the water adding portion and the crude oil are provided.

[0010] Further, it is preferred that a crude oil sludge tank for storing the crude oil sludge and a sludge supplying portion for supplying the crude oil sludge to crude oil from the crude oil sludge tank are provided.

[0011] Further, it is preferred that a crude oil returning portion for returning the crude oil processed by the processing portion to the tank and a discharging portion for discharging impurities separated from the crude oil processed by the processing portion, from the processing portion are provided.

[0012] In order to solve the above problems, the present invention is a crude oil processing apparatus characterized by including: a processing portion for applying a voltage to crude oil including crude oil sludge to generate an

electrostatic field region to process the crude oil; and a crude oil supplying portion for supplying crude oil pumped up out of ground to the processing portion.

[0013] Further, it is preferred that the processing portion applies a voltage within a range of 10,000 volts to 40,000 volts.

[0014] In order to solve the above problems, the present invention is a crude oil processing method characterized by including a process for applying a voltage to crude oil including crude oil sludge, the crude oil being stored in a tank, to generate an electrostatic field region to process the crude oil.

[0015] Further, it is preferred that a process for stirring the crude oil sludge included in the crude oil stored in the tank is included.

[0016] Further, it is preferred that a process for adding water to the crude oil before applying the voltage to the crude oil and a process for stirring the crude oil and the water are included.

[0017] Further, it is preferred that water corresponding to 5vol% to 10vol% of a crude oil amount to be processed is added to the crude oil.

[0018] Further, it is preferred that a process for mixing crude oil sludge into the crude oil before processing the crude oil by application of the voltage is included.

[0019] Further, it is preferred that a process for adding additive for accelerating destruction/dissolution of emulsion existing in the crude oil or the crude oil sludge is included.

[0020] Further, it is preferred that a process for returning the crude oil processed by application of the voltage to the tank and a process for discharging impurities separated from the crude oil processed by application of the voltage are included.

[0021] In order to solve the above problems, the present invention is a crude oil processing method characterized by including a process for applying a voltage to crude oil including crude oil sludge, the crude oil being pumped up out of ground, to generate an electrostatic field region to process the crude oil.

Effects of Invention

[0022] According to the present invention, while a lot of problems that occur at the time of discharging crude oil sludge from inside a tank are improved, it is possible to efficiently recover a lot of oil from discharged crude oil sludge, and special sludge discharge work performed by stopping operation of a crude oil tank to remove crude oil sludge becomes unnecessary.

Brief Description of Drawing

[0023]

[Fig. 1] A schematic diagram showing a configuration of a crude oil processing apparatus.

Description of Embodiment

[0024] A preferred embodiment of the present invention will be described with reference to drawings. Note that the embodiment shown below is one example and can take various forms within the scope of the present invention.

[0025] <Crude oil processing apparatus>

Fig. 1 is a schematic diagram showing a configuration of a crude oil processing apparatus.

As shown in Fig. 1, a crude oil processing apparatus 100 is provided with tanks 1 to 5, a produced crude oil processing apparatus 6, a sludge stirring portion 7, a processing portion 8, a water adding portion 9, a water stirring

portion 10, a sludge supplying portion 11, a crude oil returning portion 12 and a discharging portion 13.

[0026] (Tank)

The tanks 1 and 2 are tanks for storing crude oil O including crude oil sludge S, and the crude oil sludge S has accumulated on bottom portions of the tanks 1 and 2. The tank 3 is a tank for storing crude oil with a high concentration of the crude oil sludge S, and, for example, crude oil after being processed in the COW method, crude oil unloaded after stirring crude oil sludge near a bottom portion (a cargo bottom) of a storage tank of a crude oil tanker with crude oil, or the like is stored. The tank 4 is a tank for storing crude oil for diluting crude oil in which much crude oil sludge is included. Specifically, crude oil to be mixed with crude oil sludge to be sent from inside a tank 5 to the processing portion 8 is stored. The tank 5 is a crude oil sludge tank for storing discharged crude oil sludge after discharging the crude oil sludge accumulated in a tank storing crude oil.

The tanks 1 to 5 are arranged in parallel via conduits and integrated into one conduit on the way and connected to the processing portion 8.

[0027] Here, in many cases, crude oil sludge includes each of a moisture content (existing as emulsion) in a range of 10% to 40%, a solid content (asphaltene, semicarbon and inorganic matter) in a range of 10% to 30% and an oil content (wax and accompanying crude oil surrounded by sludge) in a range of 30% to 80%. The emulsion in the crude oil sludge is of a water-in-oil type. Outer film matter around fine water drops is a part of asphaltene, and highly carbonized hydrocarbon-based solids and inorganic solids, and, for all the kinds, solids are mainly ultrafine solids with a particle size of a few μm or less. An outer film is formed in a state in which wax and heavy oil are mixed with these solids. A particle size for the whole emulsion is estimated to 50 μm or less,

and a structure of the emulsion is strong, difficult to destroy or dissolve, and stable.

[0028] The tank 1 is connected to a conduit 21. The tank 2 is connected to a conduit 22. The tank 3 is connected to a conduit 23. The tank 4 is connected to a conduit 24. The tank 5 is connected to a conduit 25.

The conduits 21 to 25 are respectively connected to the tanks 1 to 5 on one end, while another end of each of the conduits 21 to 25 is connected to one conduit 27. The conduit 27 is connected to a conduit 28, and the conduit 28 is connected to the processing portion 8.

[0029] (Produced crude oil processing apparatus)

The produced crude oil processing apparatus 6 is for performing removal of gas and moisture included in crude oil produced from a crude oil well G (crude oil pumped up out of the ground) and the like. The produced crude oil processing apparatus 6 is connected to a conduit 26 and branches to a conduit 26a and a conduit 26b on the conduit 26. The conduit 26a is connected to the conduit 27, and the conduit 26b branches on the way and connected to the tank 1 and the tank 2. That is, there are two conveyance routes for crude oil sent from the produced crude oil processing apparatus 6. One is a route of being sent to the processing portion 8 via the water adding portion 9 and the water stirring portion 10, and the other is a route of being sent to the tank 1 or the tank 2. The produced crude oil processing apparatus 6 also functions as a crude oil supplying portion for supplying crude oil to the processing portion 8.

[0030] (Sludge stirring portion)

The sludge stirring portion 7 is provided, for example, in each of the tanks 1 and 2. On a bottom in the tank 1, a mixer 7a as the sludge stirring portion 7 is provided. The mixer 7a is for stirring the crude oil sludge S accumulated on the bottom of the tank 1 to mix the crude oil sludge S with

surrounding crude oil. Furthermore, a pump 7b as the sludge stirring portion 7 is provided in the tank 1. The pump 7b is for sucking crude oil in the tank 1 and sending the crude oil to the mixer 7a as high-pressure fluid. The pump 7b is arranged so as to jet the crude oil toward the crude oil sludge S stimulated on the bottom of the tank 1, and the pump 7b stirs the crude oil sludge S stimulated on the bottom of the tank 1 and mixes the crude oil sludge S with the surrounding crude oil.

On a bottom in the tank 2, a mixer 7c as the sludge stirring portion 7 is provided. The mixer 7a is, for example, an electric propeller mixer and is for stirring the crude oil sludge S accumulated on the bottom of the tank 2 to mix the crude oil sludge S with surrounding crude oil. Furthermore, a pump 7d as the sludge stirring portion 7 is provided in the tank 2. The pump 7d is arranged so as to suck crude oil in the tank 2 and jet the crude oil toward the crude oil sludge S accumulated on the bottom of the tank 2. The pump 7d stirs the crude oil sludge S accumulated on the bottom of the tank 2 to mix the crude oil sludge S with surrounding crude. Note that the mixer 7c and the pump 7d may be used together, or any one of the mixer 7c and the pump 7d may be provided.

Note that the sludge stirring portion 7 is not limited to being provided in the tanks 1 and 2 but may be provided in other tanks. Further, equipment and machines for mixing crude oil sludge with crude oil and stirring are not limited to the above, but other methods are also possible.

[0031] (Sludge supplying portion)

The conduit 21 is provided with a pump 31a to send out the crude oil in the tank 1 toward the processing portion 8 and a switching valve 31b provided on a downstream side of the pump 31a.

The conduit 22 is provided with a pump 32a to send out the crude oil in the tank 2 toward the processing portion 8 and a switching valve 32b provided on a downstream side of the pump 32a.

The conduit 23 is provided with a pump 33a to send out the crude oil in the tank 3 toward the processing portion 8 and a switching valve 33b provided on a downstream side of the pump 33a.

The conduit 24 is provided with a pump 34a to send out the crude oil in the tank 4 toward the processing portion 8 and a switching valve 34b provided on a downstream side of the pump 34a.

The conduit 25 is provided with a pump 35a to send out crude oil (crude oil sludge) in the tank 5 to the processing portion 8 and a switching valve 35b provided on a downstream side of the pump 35a.

The conduit 26a branching from the conduit 26 is provided with a switching valve 36a. By opening the switching valve 36a, crude oil processed by the produced crude oil processing apparatus 6 is sent to the processing portion 8 through the conduit 26a and the conduit 27. The conduit 26b branching from the conduit 26 is provided with a switching valve 36b. By opening the switching valve 36b, crude oil processed by the produced crude oil processing apparatus 6 is sent to the tanks 1 and 2 through the conduit 26b. That is, by opening any of the switching valves 36a and 36b, a destination to send crude oil can be selected.

The conduits 21, 22, 23 and 26 constitute the sludge supplying portion and can open the conduit 24 or the conduit 26a according to crude oil sludge concentration or a processing state of the processing portion 8 to appropriately add crude oil to crude oil sludge. For example, high-density sludge in the conduit 25 can be supplied after adjusting the sludge density by using the conduit 24 together. For adjustment of the sludge density in the sludge

supplying portion, the conduits can be freely selected. One conduit may be selected, or two more conduits may be selected.

[0032] (Water adding portion)

The water adding portion 9 is for adding water to crude oil and is provided with a conduit 91 and a switching valve 92 provided on the conduit 91. One end of the conduit 91 is connected to water supply equipment such as a water tank, and another end is connected to the conduit 28. That is, by opening the switching valve 92, water can be supplied into the conduit 28 in which crude oil flows. Note that it is not necessarily required to supply water from the water adding portion 9 to the conduit 28, and it can be decided whether or not to supply water according to a state of crude oil sent to the processing portion 8.

[0033] (Water stirring portion)

The water stirring portion 10 is provided on a downstream side of a point of connection with the conduit 91 of the water adding portion 9 on the conduit 28. The water stirring portion 10 is for causing water and crude oil to be mixed and is configured, for example, with a mixing valve or line mixer 10. By mixing by the water stirring portion 10, emulsion is further generated between crude oil and crude oil sludge mixed in the crude oil, and water. By the emulsion generated by the water stirring portion 10 being added, dissociation of emulsion is accelerated by electrostatic processing by the processing portion 8, and efficiency of dissolution of emulsion that has originally existed in the crude oil sludge is increased.

[0034] (Processing portion)

The processing portion 8 is a high voltage electrostatic field treatment apparatus and is generally operated under an environment of 50 to 150°C, especially under an environment of around 130°C. The processing portion 8 is

provided with a processing vessel 80, a distributor 81, electrode plates 82 and a high voltage transformer 83.

The processing vessel 80 is formed, for example, in an oval cylindrical shape when seen from a front in a state of being installed. The conduit 28 is connected to a bottom portion of the processing vessel 80, and crude oil including the crude oil sludge S is supplied from the bottom portion of the processing vessel 80. Further, to the bottom portion of the processing vessel 80, the discharge tube 13 as a discharging portion for discharging impurities such as moisture left after crude oil is processed. There is an exit for crude oil processed by the processing portion 8 on a ceiling portion of the processing vessel 80, and a conduit 12 is connected to the exit. The conduit 12 is branched on the way. A conduit 12a is a crude oil returning portion connected to each of the tanks 1 to 4, and a conduit 12b is connected to a crude oil distillation apparatus 14.

The distributor 81 equally sends out crude oil sent from the conduit 28 to the processing vessel 80 and is provided over the whole bottom portion in the processing vessel 80.

The electrode plates 82 form an electrostatic field region around the electrode plates 82 by application of a voltage. Water particles in emulsion included in crude oil are electrically charged by the formed electrostatic field region. By the water particles mutually coalescing, the emulsion is dissociated and separated into moisture and oil. Dissociation of emulsion and coalescence of water particles are repeated, and moisture coagulates, sediments and stays on the bottom portion of the processing vessel 80. The plurality of electrode plates 82 are provided side by side at predetermined intervals near a central part in a height direction in the processing vessel 80. Though the electrode

plates 82 are commonly metal plates, composite FRP plates or other electrode panels may be used.

The high voltage transformer 83 is electrically connected to the electrode plates 82 and applies a high voltage to the electrode plates 82. The high voltage transformer 83 applies a high voltage within a range of 10,000 volts to 40,000 volts to the electrode plates 82. A power source of the high voltage transformer 83 may be an AC or DC power source, or an AC/DC hybrid power source is also possible. An applied voltage and an applied frequency of the high voltage transformer 83 may be of a constant type or a variable type. As for the processing portion 8, there are an AC type, a cross-flow type, a voltage-variable cross-flow type and a frequency-variable cross-flow type. Emulsion dissolution performance increases in this order, and a processing portion of the frequency-variable cross-flow type has the highest processing capacity.

[0035] <Crude oil processing method>

Next, a crude oil processing method using the above crude oil processing apparatus will be described.

In the tank 1, the mixer 7a and the pump 7b are started, and the crude oil sludge S in the tank 1 is stirred, and the crude oil sludge S and the crude oil O are mixed. After the crude oil sludge S and the crude oil O are sufficiently mixed in the tank 1, the pump 31a is started, and the switching valve 31b is opened to send crude oil to the processing portion 8. Further, the switching valve 92 of the water adding portion 9 is opened; water is poured into the conduit 91 to send the water into the conduit 28 in which crude oil is flowing; and the crude oil and the water are sufficiently mixed via the mixing valve 10. Here, it is preferable to add an amount of water of 5 vol% to 10 vol% relative to an amount of crude oil (volume) to be processed.

In the tank 2, the mixer 7c and the pump 7d are started, and the crude oil sludge S in the tank 2 is stirred, and the crude oil sludge S and the crude oil O are mixed. After the crude oil sludge S and the crude oil O are sufficiently mixed in the tank 2, the pump 32a is started, and the switching valve 32b is opened to send the crude oil to the processing portion 8. Further, the switching valve 92 of the water adding portion 9 is opened; water is poured into the conduit 91 to send the water into the conduit 28 in which crude oil is flowing; and the crude oil and the water are sufficiently mixed via the mixing valve 10. Here, it is preferable to add an amount of water of 5 vol% to 10 vol% relative to an amount of crude oil (volume) to be processed.

In the tank 3, the pump 33a is started, the switching valve 33b is opened, and crude oil is sent to the processing portion 8. Further, the switching valve 92 of the water adding portion 9 is opened; water is poured into the conduit 91 to send the water into the conduit 28 in which crude oil is flowing; and the crude oil and the water are sufficiently mixed via the mixing valve 10. Here, it is preferable to add an amount of water of 5 vol% to 10 vol% relative to an amount of crude oil (volume) to be processed.

[0036] In the tank 4, the pump 34a is started, the switching valve 34b is opened, and crude oil is sent to the processing portion 8. Further, the switching valve 92 of the water adding portion 9 is opened; water is poured into the conduit 91 to send the water into the conduit 28 in which crude oil is flowing; and the crude oil and the water are sufficiently mixed via the mixing valve 10. Here, it is preferable to add an amount of water of 5 vol% to 10 vol% relative to an amount of crude oil (volume) to be processed.

In the tank 5, the pump 35a is started, the switching valve 35b is opened, and crude oil is sent to the processing portion 8. Further, the switching valve 92 of the water adding portion 9 is opened; water is poured into the

conduit 91 to send the water into the conduit 28 in which crude oil is flowing; and the crude oil and the water are sufficiently mixed via the mixing valve 10. Here, it is preferable to add an amount of water of 5 vol% to 10 vol% relative to an amount of crude oil (volume) to be processed.

In the produced crude oil processing apparatus 6, the switching valve 36a is opened, and crude oil is sent to the processing portion 8. Further, the switching valve 92 of the water adding portion 9 is opened; water is poured into the conduit 91 to send the water into the conduit 28 in which crude oil is flowing; and the crude oil and the water are sufficiently mixed via the mixing valve 10. Here, it is preferable to add an amount of water of 5 vol% to 10 vol% relative to an amount of crude oil (volume) to be processed.

[0037] When the crude oil sent from each of the tanks 1 to 5 and the produced crude oil processing apparatus 6 reaches the processing portion 8, emulsion is destroyed by receiving action of an electrostatic field that occurs by a voltage within 10,000 volts to 40,000 volts being applied to the electrode plates 82 from the high voltage transformer 83. Oil and fine solids separated by the destruction of the emulsion move to a crude oil side and are returned to each of the tanks 1 to 4 through the conduit 12a from an upper part in the processing vessel 80 or sent to the crude oil distillation apparatus 14 through the conduit 12b. As for moisture and heavy solids which are impurities are discharged outside through the discharge tube 13 from a lower part of in the processing vessel 80. Therefore, since a closed loop flow for returning crude oil is constructed by the conduit 12a, the above operation is repeated as far as operation of each portion is continued, and oil in the crude oil sludge S included in each of the tanks 1 to 5 and the produced crude oil processing apparatus 6 is returned to crude oil, and impurities (unnecessary matter) in the crude oil are discharged outside. Further, in the case where oil is sent to the

crude oil distillation apparatus 14 through the conduit 12b, impurities in the crude oil are decreased, which significantly contributes to safe operation and corrosion prevention of the apparatus.

Note that additive for accelerating destruction/dissolution of emulsion existing in crude oil may be added to any of the tanks 1 to 5, the produced crude oil processing apparatus 6, the conduits 21 to 28 and the processing portion 8. Thereby, it is possible to accelerate recovery of oil in crude oil.

[0038] <Operation>

According to the crude oil processing apparatus 100 and the crude oil processing method that have been described above, by water being added while the crude oil O including the crude oil sludge S is being sent to the processing portion 8 from the tanks 1 to 5 and the produced crude oil processing apparatus 6, and the crude oil O and the water being stirred by the mixing valve 10, hydrophilic components (water-soluble impurities) in the crude oil are dissolved into water, fine particles surrounded by oil and solids, so-called emulsion, are generated. This newly generated emulsion almost uniformly and gradually moves upward by the distributor 81 in the processing vessel 80 in a state of being dispersed in the crude oil together with emulsion that has originally existed in the crude oil sludge and, after a while, enters an electrostatic field region formed by the electrode plates 82 to which a high voltage is applied. The emulsion that has entered the electrostatic field region is transformed by water particles being electrically charged, and the emulsion is dissolved. Pockets of moisture separated by the emulsion being dissociated repeat mutual coalescence and coagulation by electrostatic coagulation, grow to be water drops and sediment on the bottom portion of the processing vessel 80, and the water drops are discharged outside from the discharge tube 13. Due to

the dissociation of the emulsion, ultrafine solids of about 20 μm or less, among solids constituting the emulsion, float in the crude oil and are sent to each of the tanks 1 to 4 or the crude oil distillation apparatus 14 through the conduit 12 from the upper part in the processing vessel 80. The hydrophilic components (water-soluble impurities) dissolve into moisture, and heavy solids such as iron sulfide also sediment on the bottom portion of the processing tank 80 together with the moisture and are discharged outside from the discharging portion 13.

[0039] Thereby, most of oil in the crude oil sludge S is recovered and returned to the tanks for storing crude oil, and it is possible to reduce volume of the crude oil sludge and reduce a cost of processing the crude oil sludge S. Further, when the crude oil sludge S is sent to the crude oil distillation apparatus 14, oil in the crude oil sludge S is also recovered, and stable operation of the apparatus becomes possible due to reduction in impurities.

Further, since a configuration is made in which oil in crude oil processed by the processing portion 8 is returned to tanks, and only impurities such as moisture are discharged, it is possible to cause the crude oil to circulate in the crude oil processing apparatus 100 and improve quality of the crude oil by increasing the number of circulations. Thereby, it is possible to solve the problem of quality deterioration of crude oil in the COW method and solve the problem of insufficiency of recovery of oil.

Further, since the crude oil sludge S that accumulates in a crude oil tank decreases by repeating the circulation, and, furthermore, most of the crude oil sludge S disappears, a cost (economic efficiency), a work period (workability) and safety and environmental protection accompanying removal of crude oil sludge and oil recovery can be epochally improved.

Further, since it is not necessary to stop operation of a tank at the time of processing the crude oil sludge S as done conventionally, and the crude oil

sludge S is processed during daily operation, workability is remarkably improved, and the cost can be significantly reduced.

[0040] <Others>

Note that the present invention is not limited to the above embodiment but can be appropriately changed within a range not beyond the scope of the present invention. For example, though a total of five tanks are arranged side by side in parallel in the above embodiment, only such a configuration is required that there is at least one tank in which crude oil including crude oil sludge is stored, the crude oil including the crude oil sludge is sent from the tank to a processing portion, and only oil in the crude oil processed by the processing portion is returned to the tank. Further, the number of tanks is arbitrary and can be freely changed according to a scale of processing of crude oil. Further, a combination of tanks to be used for processing, that is, a combination of crude oils to be processed can be freely changed. For example, according to sludge concentrations such as sludge concentrations of crude oil depending on a stirring state in the tank 1 and the tank 2, a sludge concentration of sludge-mixed crude oil in the tank 3 and a sludge concentration in the tank 5, and concentrations and condition of the crude oil sludge, a plurality of tanks including the tank 4 are used concurrently, and crude oil of mixture of the oils is sent to the processing portion 8. Further, produced crude oil may be added to the mixture via the produced crude oil processing apparatus 6.

[0041] Further, though the tanks 1 to 5, the produced crude oil processing apparatus 6, the crude oil distillation apparatus 14 and the like are provided in one crude oil processing apparatus 100 in Fig. 1, what kinds of tanks 1 to 5 are to be installed and whether the produced crude oil processing apparatus 6 is to be installed or not can be appropriately changed according to characteristics of

a place where crude oil processing is performed. There may be a place where at least one of the tanks 1 to 5 and the processing portion 8 are installed like a refinery, and there may be a place where the produced crude oil processing apparatus 6 and the processing portion 8 are installed like a production site of oil where the crude oil well G exists. A place where at least one of the tanks 1 to 5, the produced crude oil processing apparatus 6 and the processing portion 8 are installed like the above embodiment is also possible.

Further, addition of water to crude oil is also arbitrarily performed. Though an effect of destroying emulsion and separating oil is greater by adding water, whether or not to add water may be appropriately and freely determined according to quality of crude oil (an amount of moisture included in the crude oil). Though an amount of water to be added is normally about 5 to 10% as described above, a larger amount is possible, and a part of wastewater at an exit of the processing portion may be recycled. A place to perform water addition is also arbitrary, and it is only necessary to provide the place on a route connecting a tank and the processing portion.

Further, the water stirring portion is not limited to a mixing valve but may be a line mixer.

Further, as for a processing portion, any apparatus may be used if the apparatus can destroy emulsion in crude oil by formation of an electrostatic field region.

[Example]

[0042] Next, an example of crude oil processing using a crude oil processing apparatus will be described.

Using light crude oil produced in Middle East is used as a crude oil sample, tests were conducted under an environment of 80°C using a total of six kinds of samples, combinations obtained by adding 4vol%, 8vol% and 12vol%

of water to each of crude oil including 1wt% of crude oil sludge and crude oil including 3wt% of crude oil sludge.

For evaluation, BS&W, one of major indicators of crude oil quality, was used. BS&W is unnecessary matter in crude oil, and an analysis method is defined in JIS and ASTM. As an operation indicator in crude oil commercial transactions and refineries, BS&W is widely used. Crude oil sludge is a general name for a mixture of emulsion, crystal wax, inorganic precipitates and, furthermore, accompanying crude oil surrounding by the sludge components and the like. Since methods or standards for analyzing crude oil sludge itself do not exist, it is thought most appropriate to make BS&W an indicator as a scale indicating unnecessary components in crude oil sludge. BS&W is obtained by stirring and mixing a sample with an equal amount of warm toluene and, after that, separating toluene insoluble solids by a centrifugal separation method and measuring the toluene insoluble solids. Specifically, BS&W is a sum total of moisture and toluene insoluble solids separated by a certain centrifugal force. Therefore, an idea that BS&W (vol%), which is a total of total moisture and toluene insoluble solids in emulsion which is a main component of crude oil sludge, represents unnecessary components in the crude oil sludge is proper.

In general, BS&W of crude oil sludge is often about 20vol% to 50vol% though BS&W varies according to crude oil types, storage histories and the like. Components other than BS&W components are oil and asphaltene. Crude oil with a high concentration of BS&W in which crude oil sludge is mixed is processed by a high voltage electrostatic field region to dissolve emulsion, which is a main component of the sludge. All of oil separated by the dissolution is recovered to crude oil, and moisture can be discharged as wastewater. Therefore, after the processing by the high voltage electrostatic

field region, BS&W in the crude oil is significantly reduced, which significantly contributes to stable operation in a crude oil commercial transaction or a refinery.

Almost all of oil in a sludge component introduced into the processing portion 8 is transferred to crude oil in the processing portion 8 and recovered. Undissolved emulsion is discharged from the upper part together with crude oil, and a dissolution rate at that time is used as test data in a laboratory tester (an emulsion stability tester) imitating the processing portion 8, as a BS&W removal rate. Table 1 shows test conditions, and Table 2 shows test results.

[0043] [Table 1]

CRUDE OIL SAMPLE	LIGHT MIDDLE EAST CRUDE OIL
SLUDGE SAMPLE	MIDDLE EAST CRUDE OIL SLUDGE
MOISTURE CONTENT	21
BS (BASIC SEDIMENT): MUD CONTENT	4
ASPHALTENE	11
OIL CONTENT	64
TEST TEMPERATURE	80°C
AMOUNT OF ADDED CRUDE OIL SLUDGE (WT%)	1,3
AMOUNT OF ADDED WATER (VOL%)	4,8,12

[0044] [Table 2]

AMOUNT OF ADDED CRUDE OIL SLUDGE (WT%)	AMOUNT OF ADDED WATER (VOL%)	BS&W IN CRUDE OIL SAMPLE BEFORE PROCESSING (VOL%)	BS&W IN CRUDE OIL SAMPLE AFTER PROCESSING (VOL%)	BS&W REMOVAL RATE
1	4	0.25	0.05	80
1	8	0.25	0.1	60
1	12	0.25	0.1	60
3	4	0.75	0.1	87
3	8	0.75	0.15	80
3	12	0.75	0.15	80

*1 BS&W in raw oil is BS&W brought in only from crude oil sludge, without including an amount of added water, and calculated values from a sludge sample analysis result of the above table are shown.

[0045] As seen from the test results shown in Table 2, many of rates of removal of BS&W in samples reach 80%. When tests are conducted at a test temperature of 50°C, the BS&W removal rates are generally 50% or below. As the temperature is higher, dissolution of emulsion is accelerated, and the BS&W removal rate increases. When it is considered that a normal operation condition of the processing portion 8 is 100 to 150°C, a BS&W removal rate is estimated to be 80% or above in the processing portion 8 which is actually used.

As described above, it has been confirmed that the crude oil processing apparatus 100 is effective in recovery of oil from crude oil sludge.

List of Reference Signs

[0046]

1, 2, 3, 4 tank (crude oil tank)

- 5 tank (crude oil sludge tank)
- 6 produced crude oil processing apparatus
- 7 sludge stirring portion
- 7a, 7c mixer
- 7b, 7d pump
- 8 processing portion
- 9 water adding portion
- 10 mixing valve (water stirring portion)
- 11 sludge supplying portion
- 12 conduit (transfer routes for crude oil returning portion and crude oil distillation apparatus)
- 13 discharge tube (discharging portion)

Claims

1. A crude oil processing apparatus characterized by comprising:
a tank for storing crude oil including crude oil sludge; and
a processing portion for applying a voltage to the crude oil supplied from the tank to generate an electrostatic field region to process the crude oil.
2. The crude oil processing apparatus according to claim 1, characterized by comprising a sludge stirring portion for stirring the crude oil sludge accumulating in the tank; wherein
the processing portion processes the crude oil stirred by the sludge stirring portion.
3. The crude oil processing apparatus according to claim 1 or 2, characterized by comprising:
a water adding portion for adding water to the crude oil; and
a water stirring portion for stirring the water added by the water adding portion and the crude oil.
4. The crude oil processing apparatus according to any one of claims 1 to 3, characterized by comprising:
a crude oil sludge tank for storing the crude oil sludge; and
a sludge supplying portion for supplying the crude oil sludge to crude oil from the crude oil sludge tank.
5. The crude oil processing apparatus according to any one of claims 1 to 4, characterized by comprising:

a crude oil returning portion for returning the crude oil processed by the processing portion to the tank; and

a discharging portion for discharging impurities separated from the crude oil processed by the processing portion, from the processing portion.

6. A crude oil processing apparatus characterized by comprising:

a processing portion for applying a voltage to crude oil including crude oil sludge to generate an electrostatic field region to process the crude oil; and

a crude oil supplying portion for supplying crude oil pumped up out of ground to the processing portion.

7. The crude oil processing apparatus according to any one of claims 1 to 6, characterized in that the processing portion applies a voltage within a range of 10,000 volts to 40,000 volts.

8. A crude oil processing method characterized by comprising a process for applying a voltage to crude oil including crude oil sludge, the crude oil being stored in a tank, to generate an electrostatic field region to process the crude oil.

9. The crude oil processing method according to claim 8, characterized by comprising a process for stirring the crude oil sludge included in the crude oil stored in the tank.

10. The crude oil processing method according to claim 8 or 9, characterized by comprising:

a process for adding water to the crude oil before applying the voltage to the crude oil; and

a process for stirring the crude oil and the water.

11. The crude oil processing method according to claim 10, characterized in that water corresponding to 5vol% to 10vol% of a crude oil amount to be processed is added to the crude oil.

12. The crude oil processing method according to any one of claims 8 to 11, characterized by comprising a process for mixing crude oil sludge into the crude oil before processing the crude oil by application of the voltage.

13. The crude oil processing method according to any one of claims 8 to 12, characterized by comprising a process for adding additive for accelerating destruction/dissolution of emulsion existing in the crude oil or the crude oil sludge.

14. The crude oil processing method according to any one of claims 8 to 13, characterized by comprising:

a process for returning the crude oil processed by application of the voltage to the tank; and

a process for discharging impurities separated from the crude oil processed by application of the voltage.

15. A crude oil processing method characterized by comprising a process for applying a voltage to crude oil including crude oil sludge, the crude

oil being pumped up out of ground, to generate an electrostatic field region to process the crude oil.