

**Carrying Method of Crude Oil and Naphtha by
Dirty/Crude Oil Carrier, and Transfer Method of
the Crude Oil and Naphtha from the Carrier**

Technical Field

The present invention relates to a method of transferring crude oil and naphtha to a land storage tank from a carrier.

Background Art

As a carrier for use in carrying oil, in general, a tanker has been used which can carrying a large amount of oil at once. Moreover, the tanker includes: a dirty oil tanker (carrier) for carrying the crude oil produced from an oil field and fuel oil; and a clean oil tanker for carrying clean products (white oil) such as naphtha, kerosene, and light oil, that is, other clean refined products such as gas oil.

For the crude oil tanker for carrying the crude oil, a very large crude carrier (VLCC) is a mainly used, and it is high in carry efficiency and carries 200,000 tons or more.

Unless a big terminal is provided as a rare case, it is difficult for crude oil supertankers such as the VLCC to come alongside the pier in general ports and harbors. Therefore, usually, the tanker is brought alongside a terminal for cargo handling called a sea berth and installed in the sea, and the crude oil is unloaded.

Alternatively, while the tanker is moored onto a sea buoy in the vicinity of the harbor, the crude oil is unloaded. Moreover, after the crude oil tanker arrives at the sea berth of a destination, a piping is used to transfer the crude oil to a crude oil tank on land from a tank of the crude oil tanker.

On the other hand, in general, the clean oil products is carried by a clean oil products carrier. When the clean oil tanker arrives at the sea berth of the destination, a piping for the clean oil products is used to transfer the clean oil products to a land clean oil products tank from a tank of the clean oil products carrier.

However, in some case, the crude oil tanker having reached the sea berth is connected to the land tank built apart from the tanker usually by several kilometers only by the piping for the crude oil, and the exclusive piping for transferring clean oil products (such as naphtha) is not installed. In this case, there has been a demand for the transfer of clean oil products to the tank on land via the piping for the crude oil.

The clean oil products is one of refined materials obtained in a process of oil refining, and further distilled, or used as such, when it is not necessary to perform a distillation treatment. The clean oil products is used as raw material clean oil products of an ethylene manufacturing plants (thermal decomposition plants) or an aromatic series manufacturing plants.

Moreover, the material clean oil products is

requested not to contain more than a given ratio of heavy compounds.

Furthermore, the "given ratio" means the ratio of heavy compounds contained in the clean oil products, which is determined by a treatment capability in the ethylene manufacturing plants (thermal decomposition plants) or aromatic series manufacturing plants with respect to the heavy compounds.

Contrary to the above-described request, however, when one piping is used to transfer the clean oil products and crude oil in batches, the crude oil is mixed in the clean oil products. As a result, the clean oil products contains heavy compounds such as the crude oil in a certain ratio or a higher ratio, and cannot be used as the material clean oil products unless the distillation treatment is performed.

Therefore, there has been a demand for a technique for transferring the crude oil and clean oil products without mixing the crude oil with the clean oil products, or with a minimized mixed amount of the crude oil.

From this viewpoint, there have been proposed several techniques for transferring the crude oil and the clean oil products with one piping.

For example, a technique of a method of carrying the clean oil products with a pipeline for crude oil has been proposed in Japanese Patent Application Laid-Open No. 2001-108200.

This technique comprises: carrying the lot of clean

oil products held between two lots of condensate including head and tail lots of condensate via the pipeline for crude oil; and recovering the lot of clean oil products at an outlet of the pipeline, when passing through a boundary surface of head condensate/clean oil products or before substantially completely passing through the boundary surface, and when a boundary surface region of clean oil products/tail condensate appears or after the region substantially appears.

Moreover, in this technique, to use the pipeline whose total length extends about several hundreds of kilometers to transfer the crude oil and clean oil products, a timing to recover the lot of clean oil products is determined by colorimetry or specific gravity measurement of a transfer fluid.

However, when the technique described in the Japanese Patent Application Laid-Open No. 2001-108200 is used to transfer the crude oil and clean oil products, the condensate is used as a special partition agent, therefore a transfer step becomes complicated, and further it is necessary to newly dispose a recovery apparatus of condensates. This increases the cost and results in a problem that the technique is not practical.

Moreover, in this technique, since the boundary of the crude oil and clean oil products is determined by the colorimetry or specific gravity measurement of the transfer fluid, it is impossible to precisely obtain the timing to change the receiver tank. This results in a problem that

the crude oil amount to be mixed in the clean oil products cannot be minimized. This problem becomes remarkable as the pipeline (piping distance) lengthens.

Additionally, it is also assumed that solutions (such as water) described in Japanese Patent Publication No. 1981-21960 are used as the special partition agent for separating the clean oil products and crude oil to transfer the clean oil products (such as naphtha) with the piping for the crude oil. However, also in this case, a problem is that the transfer step is complicated.

The present invention has been developed in consideration of the above-described problems, and a object thereof is to provide a transfer method of crude oil and clean oil products in which one piping can be used to transfer the clean oil products and crude oil to a storage tank from a carrying tank in batches without using any special partition agent for separating the crude oil.

Disclosure of Invention

To achieve the object, as a result of intensive researches, the inventors of the present invention have carried out a flow analysis (sometimes hereinafter referred to as "fluid analysis") of crude oil, naphtha, and mixed fluid including the crude oil and naphtha in the piping in a time when a piping for the crude oil is used to alternately transfer the naphtha and crude oil to the storage tank from the carrying tank. The inventor has

found that a transfer method can be used based on the flow analysis to transfer the naphtha in a state for inhibiting the naphtha from being contaminated with the crude oil without using any special partition agent, and has completed the present invention.

Thereby, even when there is only the piping for the crude oil between the crude oil tanker and the tank on land, and there is not the exclusive-use piping for transferring the naphtha, it is possible to carrying the naphtha together with the crude oil with a large-scaled crude oil tanker. As compared with the carrying with a conventional naphtha ship, the carrying cost can largely be reduced.

Concretely, for a transfer method of the crude oil and naphtha of the present invention, according to claim 1, there is provided a method of transferring the crude oil and naphtha with one piping to a storage tank from a carrying tank, the method comprising:

- (1) using the piping to discharge the naphtha or crude oil to the storage tank from the carrying tank, while the piping is connected to a tank for the crude oil or naphtha;

- (2) calculating an amount of the crude oil or naphtha remaining in the piping via which the carrying tank is connected to the storage tank beforehand;

- (3) discharging the naphtha or crude oil from the carrying tank, and measuring a discharge amount;

- (4) stopping the discharging of the naphtha or crude

oil from the carrying tank and changing a receiver tank to the tank for the naphtha or crude oil from the tank for the crude oil or naphtha, when the discharge amount of the naphtha or crude oil from the carrying tank is substantially the same as the pre-calculated amount of the crude oil or naphtha remaining in the piping; and

(5) restarting the discharging of the naphtha or crude oil from the carrying tank after changing the tank, and storing the naphtha or crude oil into the tank for the naphtha or crude oil.

In this case, when the crude oil or naphtha remaining in the piping is discharged, the crude oil or naphtha can be pushed out into the tank for the crude oil or naphtha by a pumping action, and the amount of the crude oil mixed into the naphtha can effectively be reduced.

Moreover, since the special partition agent for separating the naphtha and crude oil does not have to be used, the transfer step can be simplified.

In the invention according to claim 2, the method comprises: analyzing a flow of the crude oil, the naphtha, and a mixed fluid including the crude oil and naphtha in the piping; and using the flow analysis result to determine a timing at which the discharging of the naphtha or crude oil from the carrying tank is stopped.

In this manner, the mixed amount of the crude oil in the naphtha can be controlled with good precision, and it is possible to prevent disadvantages that a fixed ratio of or more heavy compounds are mixed in the naphtha, so that

the naphtha is contaminated with the heavy compounds.

In the invention according to claim 3, when the amount of the crude oil or naphtha remaining in the piping is calculated beforehand, at least a temperature, density, or specific gravity of the remaining crude oil or naphtha is used as a correction element in the method.

In this case, the flow analysis can be performed with good precision. For example, when the discharge amount of the naphtha or crude oil from the carrying tank is measured based on the amount of the crude oil or naphtha pushed out into the receiver tank, the discharge amount of the naphtha or crude oil can be measured with good precision.

Moreover, in the invention according to claim 4, a fixed scale of the receiver tank is used to measure the discharge amount of the naphtha or crude oil from the carrying tank in the method.

In this case, the discharge amount of the naphtha or crude oil from the carrying tank can simply and securely be measured, and the timing to change the receiver tank to the tank for the naphtha or crude oil from the tank for the crude oil or naphtha can be obtained with good precision.

In the invention according to claim 5, the method further comprises: changing the discharge speed of the naphtha or crude oil based on the flow analysis result, when pushing out the crude oil or naphtha remaining in the piping into the tank.

In this case, the crude oil or naphtha can be transferred, while the mixing of the crude oil with the

naphtha is minimized.

Moreover, in the invention according to claim 6, the method further comprises: changing the discharge speed of the naphtha or crude oil immediately after starting the discharging of the naphtha or crude oil and immediately before stopping the discharging.

When the discharge speed of the naphtha or crude oil is changed immediately after starting the discharging in this manner, the length of the mixed fluid of the naphtha and crude oil in the piping can be shortened, and the mixing of the naphtha and crude oil in the piping can be minimized. Moreover, when the discharge speed of the naphtha or crude oil is changed immediately before stopping the discharging, the timing to change the receiver tank to the tank for the naphtha or crude oil from the tank for the crude oil or naphtha can be obtained with good precision.

Moreover, in the invention according to claim 7, the discharge speed of the naphtha or crude oil immediately after starting the discharging of the naphtha or crude oil is rapidly raised up to a predetermined discharge speed in the method.

In this case, the mixed fluid with the crude oil and naphtha mixed therein can be formed in a short time, that is, the length of the mixed fluid of the naphtha and crude oil in the piping can be shortened.

Brief Description of the Drawings

FIG. 1 is a flowchart showing a procedure of a

carrying method of the present invention.

FIG. 2 is a schematic constitution diagram showing one example of a judgment apparatus which automatically judges and determines a crude oil tanker to be designated and the amount of naphtha loaded into the crude oil tanker.

FIG. 3 is a plan view of a crude oil supertanker for a mixed loading of the naphtha and crude oil.

FIG. 4 is a schematic block diagram showing transfer situations in an embodiment of a transfer method of the crude oil and naphtha according to the present invention.

FIG. 5 is a schematic flowchart in the embodiment of the transfer method of the crude oil and naphtha according to the present invention.

FIG. 6 shows schematic diagrams of a mixed fluid in a piping in the embodiment of the present invention, (a) shows a sectional view of a state in which the naphtha is discharged into the piping with the crude oil remaining therein, and (b) shows a sectional view of a state in which the crude oil is discharged into the piping with the naphtha remaining therein.

FIG. 7 shows a continuity equation (1), momentum equation (2), turbulence model equation (3), and diffusion equation (4) for analyzing a flow state of the present embodiment.

FIG. 8 shows schematic diagrams of an analysis example of the flow state of the present embodiment, (a) shows an analysis model diagram, and (b) shows a graph indicating a change of a discharge speed (flow rate).

FIG. 9 is a graph showing the transfer state of the crude oil and naphtha and indicating a transfer amount to a transfer time in the analysis example of the present embodiment.

FIG. 10 is a graph of a concentration curve showing a naphtha concentration distribution of a piping length direction in the analysis example of the present embodiment.

Best Mode for Carrying Out the Invention

Preferred embodiments of the present invention will be described hereinafter in detail with reference to the drawings.

[Description of Carrying Method]

FIG. 1 is a flowchart of a carrying method of the present invention.

First, a crude oil tanker for a mixed loading of the naphtha and crude oil is designated based on an amount of the naphtha or crude oil to be carried and a destination port of the crude oil tanker (step S1). In this case, a combination of the naphtha and crude oil by which a carrying cost is most inexpensive is selected from a plurality of combinations, so that the crude oil tanker may be designated and the amount of the naphtha to be loaded may be determined. Additionally, for the crude oil tanker having a possibility of the mixed loading of the naphtha and crude oil, to prevent early corrosion of components such as a tank and/or a packing because of a difference in

properties between the crude oil and naphtha, these components may be replaced with components which do not quickly or easily corrode by the naphtha and crude oil.

The designation of the crude oil tanker and the determination of the amount of the naphtha to be loaded in the crude oil tanker can be automated using judgment apparatuses such as a computer.

FIG. 2 is a schematic constitution diagram showing one example of a judgment apparatus which automatically judges and determines a crude oil tanker to be designated and the amount of the naphtha to be loaded in the crude oil tanker.

A judgment apparatus 21 includes: an input means 22 such as a keyboard for inputting a carrying plan of the crude oil and naphtha; a sailing situation monitor means 24 to monitor sailing situations of possessed crude and clean oil tankers; a read/write means 23 to write or read the carrying plan inputted from the input means 22 and the sailing situations of the crude and clean oil tankers with respect to a database 25; a processing means 26 to judge and determine the crude oil tanker to be designated and the amount of the naphtha to be loaded from the carrying plan and sailing situations of the crude and clean oil tankers; and an output means 27 such as a printer and display to output a processing result of the processing means 26.

The sailing situation monitor means 24 successively transmits the sailing situation telegraphed from the sailing crude and clean oil tankers to the read/write means

23, and writes the situations in the database 25.

The database 25 stores types and names of the possessed crude and clean oil tankers, loading capabilities of the crude and clean oil tankers, the current sailing situations (current position, destination, port of call, estimated time of arrival, and the like) of the crude and clean oil tankers inputted from the sailing situation monitor means 24, schedule of periodic inspections, and further the next carrying plan inputted from the input means 22 (carrying tons of the crude oil and naphtha, port of call (supplier of the crude oil and naphtha), destination, carrying date, and the like).

The processing means 26 determines the crude and clean oil tankers by which the carrying is possible in accordance with the carrying plan based on the sailing situations stored in the database 25. Moreover, the processing means obtains the amount of the naphtha which can be loaded from the carrying capability of the determined crude oil tanker and the amount of the crude oil to be carried by the carrying plan.

Subsequently, the processing means 26 considers the supplier (port of call) of the crude oil and naphtha indicated in the carrying plan, calculates/obtains a total carrying cost of the crude oil and naphtha in the carrying plan, increases/decreases the amount of the naphtha to be loaded if necessary, and determines the crude oil tanker and the load amount of the naphtha so that the total carrying cost is most inexpensive.

The crude oil tanker for also carrying the naphtha is determined in this manner, further the port of call and time schedule of the crude oil tanker and clean oil tanker are determined, and these are outputted to the output means 27 such as the display.

When the crude oil tanker for also carrying the naphtha is determined in the above-described procedure, an inboard tank to be loaded with the naphtha is next designated from a plurality of inboard tanks disposed in the crude oil tanker based on the amount of the naphtha to be loaded (step S2).

FIG. 3 is a schematic plan view of a crude oil supertanker such as VLCC for also carrying the naphtha.

A crude oil tanker 1 includes a plurality of inboard tanks 11. A naphtha 3 is different from crude oil 2 in density (or specific gravity, described as the density in the following). Therefore, when the naphtha 3 and crude oil 2 are both loaded and carried, it is necessary to load the naphtha 3 with good balance not to cause a trouble in the sailing of the crude oil tanker 1.

FIG. 3 shows that the naphtha is loaded into five of the plurality of inboard tanks 11. In the drawing, the inboard tanks 11 for carrying the naphtha are denoted with code N, and the inboard tanks 11 for carrying the crude oil are denoted with O. Moreover, WBT denotes a ballast tank.

As shown, the inboard tanks 11 for carrying the naphtha and the inboard tanks 11 for carrying the crude oil are designated with good balance from side to side and back

and forth with respect to a traveling direction of the crude oil tanker 1 so that a gravity center position of the crude oil tanker 1 is as immobile as possible. Additionally, for the inboard tank having a possibility that the tank is designated to carry the naphtha, a packing may be replaced with another packing such as NBR (Nitrile Butadiene Rubber) which corrodes little by the naphtha.

Moreover, to load the naphtha, it is necessary to drain the crude oil remaining in the piping of the crude oil tanker 1 on board via a drain. The inboard tanks 11 connected to the drain are to be used exclusively for the crude oil, and excluded beforehand from the designation of the inboard tanks 11 for carrying the naphtha.

When the inboard tanks for carrying the naphtha are designated, in consideration of the difference in density between the naphtha and crude oil, a level gauge disposed in each inboard tank is adjusted (step S3).

Moreover, the inside of the inboard tank for carrying the naphtha is washed, and the remaining crude oil or sludge is removed from the inboard tank as much as possible (step S4).

The inside of the inboard tank may be washed using an exclusive-use detergent or seawater, or may also be washed using the crude oil carried in the previous sailing. The remaining crude oil sticks to the inner wall surface of the inboard tank, but the amount is slight with respect to the amount of the naphtha to be loaded in the inboard tank, and the amount of the crude oil mixed with the naphtha

(material naphtha) can be set to be sufficiently not more than an allowable value. Moreover, when the remaining crude oil is drained before the loading of the naphtha, the amount of the crude oil mixed in the naphtha can be reduced.

The naphtha may be loaded after or before the loading of the crude oil. Before loading the naphtha, the crude oil and sludge remaining in the bottom of the inboard tank are preferably drained again (step S5). In this case, the amount of the crude oil mixed in the naphtha can further be reduced.

In order to prevent the mixing of the crude oil in the naphtha wherever possible, when the naphtha is loaded, the crude oil remaining in the piping of the crude oil tanker on board is drained into the inboard tank to be loaded with the crude oil (or already loaded) using the drain (step S5).

By the above-described procedure, the preparation for the loading of the naphtha is completed, and thereafter the loading of the naphtha into the designated inboard tank is started (step S6).

Additionally, in this case, in order to further reduce the amount of the crude oil mixed in the naphtha, the naphtha is loaded at a relatively low speed in an early stage after starting the loading of the naphtha, so that the crude oil or sludge remaining in the bottom of the inboard tank is not stirred.

Moreover, when the naphtha is loaded slowly in the

early stage after the start of the loading in this manner, generation of static electricity by friction of the naphtha and inboard tank can be inhibited as much as possible, and this is also advantageous in a safety aspect.

The loading of the naphtha is completed in the above-described procedure. After the completion of the loading of the naphtha, the naphtha remaining in the piping is discharged into the inboard tank loaded with the naphtha, and loss is preferably prevented wherever possible.

The naphtha and crude oil loaded in the above-described procedure are carried to the destination by a common crude oil tanker (step S7). Furthermore, when a pressure in the inboard tank rises during the sailing, water may be spread over a deck to cool the inboard tank. This can prevent the loss of the naphtha by vaporization.

Moreover, a valve for adjusting the pressure of the inboard tank may be prepared.

In the destination, either of the naphtha or crude oil may first be unloaded. If the naphtha is loaded after the crude oil during the loading, the naphtha may preferably be first unloaded. In this case, an operation of removing the crude oil from the piping on board can be omitted, and the amount of the crude oil mixed in the naphtha can also be reduced. When the naphtha is unloaded, an eductor apparatus of this ship is used to completely drain the naphtha from the inboard tank.

Moreover, if the crude oil is loaded after the naphtha during the loading, the may first be unloaded.

Subsequently, similarly as described above the crude oil in the piping is drained (step S8). After the piping is filled with the naphtha, the unloading of the naphtha is started (step S9).

Furthermore, also during the unloading, the naphtha may slowly be unloaded in the vicinity of the bottom of the inboard tank, so that crude oil or sludge remaining in the inboard tank is not stirred. Additionally, after the naphtha is unloaded, a rust proofing treatment of the inboard tank such as the washing of the inboard tank with the crude oil is preferably carried out.

When a land piping (the piping disposed on land, including a piping portion extending to the sea berth from the land on the sea) connected to a ship piping is distinguished for the naphtha and crude oil, the land piping for the naphtha may be used to unload the naphtha, and the land piping for the crude oil may be used to unload the crude oil.

According to the present invention, it is possible to carrying the naphtha using the crude oil tanker whose carrying cost is inexpensive, and therefore an effect is produced that the carrying cost of the naphtha can largely be reduced.

A concrete effect of the present invention is shown in the following table.

This table shows the reduction of the carrying cost in the mixed loading and carrying of 50,000 tons of the naphtha with the crude oil in a VLCC as the crude oil

supertanker. In 2001, the carrying cost per ton was about \$20 for the crude oil tanker, and about \$31 for the clean oil tanker oil tanker for the naphtha.

[Table]

	Carrying unit cost \$/t	Carrying tonnage	Carrying cost
VLCC	\$20	50,000 t	\$1,000,000
Clean oil tanker	\$31	50,000 t	\$1,550,000
Difference	\$11		\$ 550,000

As shown above, according to the present invention, the carrying cost can be reduced by about \$550,000 (71,500,000 yen in terms of conversion of \$1 = 130 yen) in one carrying. This indicates that the carrying cost of the naphtha can be reduced to about 2/3 of the conventional cost. Therefore, according to the present invention, the cost reduction of the material naphtha, which has heretofore been difficult, can easily and largely be achieved.

Moreover, when the properties of the unloaded material or product the naphtha were checked, a slight color change was recognized, but the mixed amount of the crude oil was very small, and was sufficiently below the allowable value prescribed by laws such as a law regulating the operation of the apparatus.

[Description of Transfer Method]

Additionally, when the land piping is not distinguished for the naphtha and crude oil, the land

piping for the crude oil can be used to unload the naphtha.

In this case, known techniques of Japanese Patent Application Laid-Open Nos. 2001-108200 and 1995-83399, and Publication No. 1982-25760 may be used to transfer the naphtha 3.

In the present embodiment, according to the following method described with reference to FIGs. 4 to 10, while the mixed amount of the crude oil is minimized, the common land piping is used to transfer the crude oil and naphtha.

FIG. 4 is a schematic block diagram showing transfer situations in the embodiment of a transfer method of the crude oil and naphtha according to the present invention.

Additionally, a bypass piping, and the like are omitted from FIG. 4 for ease of understanding.

In FIG. 4, the large-sized tanker 1 includes a plurality of inboard tanks 11 as carrying tanks, the crude oil 2 and naphtha 3 are loaded in the inboard tanks 11 different from each other so that the crude oil and naphtha are not mixed with each other, and the tanker is moored in the sea berth as the carrying destination.

Moreover, the large-sized tanker 1 usually includes a pump 12 for transferring the loaded crude oil 2 into tanks for the crude oil 4 on land. In the sea berth, a valve 51, pressure gauge 52, and piping 53 for transferring the crude oil 2 fed from the pump 12 are disposed. Furthermore, a densimeter 54 is disposed if necessary.

Furthermore, as storage tanks, a plurality of tanks 4 for the crude oil and tanks 6 for the naphtha are disposed

on land, and connected to the tip end of the piping 53 extended in the vicinity of the tanks 4, 6 via valves 61.

Additionally, FIG. 5 shows a schematic flowchart in one embodiment of the transfer method of the crude oil and naphtha according to the present invention. Concretely, an example in which the crude oil is transferred after the naphtha is shown.

According to the transfer method of the crude oil and naphtha in the present embodiment, the crude oil 2 and naphtha 3 are transferred via one piping 53. When the crude oil 2 is transferred to the respective tanks 4, 6 on land from the inboard tanks 11, first the piping 53 is connected to the tanks for the crude oil 4 (step S11).

In this case, the crude oil 2 remains in the piping 53. Therefore, first, when the naphtha 3 is transferred into the tanks 6 for the naphtha, it is necessary to discharge the naphtha 3 via the piping 53 and push the crude oil 2 in the piping 53 into the tanks for the crude oil 4 by this pumping action.

Subsequently, the amount of the crude oil 2 remaining in the piping 53 which connects the inboard tanks 11 to the respective tanks 4, 6 is calculated beforehand (step S12).

Here, usually the piping 53 having the closed valves 51, 61 is substantially filled with the crude oil 2. In this case, a capacity in the piping 53 can be calculated as the volume (amount) of the crude oil 2.

Subsequently, to start the discharge, the valves 51, 61 are opened, the naphtha 3 is discharged from the inboard

tanks 11, and the discharge amount of the naphtha 3 is measured (step S13).

The amount can be measured, for example, using a flowmeter connected to the piping 53, measuring the height of a solution surface of the inboard tank 11, or measuring the height of the solution surface of the receiver tank 4.

Subsequently, when the discharge amount of the naphtha 3 from the inboard tanks 11 is substantially the same as the pre-calculated amount of the remaining crude oil 2, the discharge of the naphtha 3 from the inboard tanks 11 is stopped, and the receiver tank is changed to the tank for the crude oil 6 from the tank for the crude oil 4 (step S14).

Additionally, substantially the same amount is described above. This is because the allowable mixed amount of the crude oil 2 into the naphtha 3 changes with the ratio of heavy compounds contained in the crude oil 2 and the total transfer amount of the naphtha 3.

Subsequently, after the receiver tank is changed to the tank 6 for the naphtha from tank for the crude oil 4, the discharge of the naphtha 3 from the inboard tanks 11 is restarted, and the naphtha 3 is stored in the tank 6 for the naphtha (step S15).

Additionally, when the transfer of the naphtha 3 from the inboard tanks 11 ends, the pump 12 of the large-sized tanker 1 stops.

As described above, according to the transfer method of the crude oil and naphtha in the present embodiment,

when the naphtha 3 is discharged, the crude oil 2 remaining in the piping 53 can be pushed out into the tanks for the crude oil 4 by the pumping action, and therefore the mixed amount of the crude oil 2 into the naphtha 3 can effectively be reduced.

Moreover, since the special partition agent for separating the naphtha 3 and crude oil 2 from each other does not have to be used, the transfer step can be simplified.

Subsequently, the crude oil 2 of the inboard tanks 11 of the large-sized tanker 1 is transferred into the tanks 4 for the crude oil.

In this case, since the naphtha 3 remains in the piping 53, it is necessary to push out the naphtha 3 in the piping 53 into the tanks 6 for the naphtha.

Therefore, the piping 53 is left to be connected to the tanks 6 for the naphtha (step S16).

Subsequently, the amount of the naphtha 3 remaining in the piping 53 which connects the inboard tanks 11 to the respective tanks 4, 6 is calculated beforehand (step S17).

Next, the crude oil 2 is discharged from the inboard tanks 11, and the discharge amount of the crude oil 2 is measured (step S18). When the discharge amount of the crude oil 2 from the inboard tanks 11 is substantially the same as the pre-calculated amount of the remaining naphtha 3, the discharge of the crude oil 2 from the inboard tanks 11 is stopped, and the receiver tank is changed to the tank 4 for the crude oil from the tank 6 for the naphtha (step

S19).

After the receiver tank is changed to the tank 4 for the crude oil from the tank 6 for the naphtha, the discharge of the crude oil 2 from the inboard tanks 11 is restarted, and the crude oil 2 is stored in the tanks 4 for the crude oil (step S20).

Additionally, when the transfer of the crude oil 2 from the inboard tanks 11 ends, the pump 12 is stopped, and the valves 51, 61 are closed. Therefore, the crude oil 2 remains in the piping 53.

In this case, when the crude oil 2 is discharged, the naphtha 3 remaining in the piping 53 can be pushed out into the tanks 6 for the naphtha by the pumping action, and the mixed amount of the naphtha 3 into the crude oil 2 can effectively be reduced.

Additionally, the present embodiment is assumed to relate to the transfer method of the crude oil and naphtha in a case in which first the naphtha 3 is discharged from the large-sized tanker 1 and subsequently the crude oil 2 is discharged. However, the order of the discharge is not especially limited, and the discharge may also be performed in the opposite order (after discharging the crude oil, naphtha is discharged). This order is determined in consideration of the loading situation (only the crude oil, or crude oil/naphtha) of the tanker to be unloaded.

In the transfer method of the crude oil and naphtha according to the present embodiment, for example, when the amount of the crude oil 2 remaining in the piping 53 is

calculated beforehand (step S12), at least a temperature or density of the remaining crude oil 2 is preferably used as a correction element.

In this case, when the discharge amount of the naphtha 3 from the inboard tanks 11 is obtained from the amount of the crude oil 2 measured using a fixed scale 42 of the tank 4 for the crude oil of a receiver, it is possible to correct a measurement error by temperature and density differences from the crude oil 2 already stored in the tanks 4 for the crude oil. Therefore, the timing to change the tank 4 for the crude oil to the tank 6 for the naphtha can be obtained with good precision.

In the present embodiment, the density can be measured by the densimeter 54 attached to the piping 53 on a pump 12 side.

Moreover, similarly as described above, also when the amount of the naphtha 3 remaining in the piping 53 is calculated beforehand (step S17), the temperature or density of the naphtha 3 may of course be used as the correction element.

Furthermore, when the discharge amount of the naphtha 3 is measured (step S13), the discharge amount of the naphtha 3 from the inboard tanks 11 may also be measured using the fixed scale 42 of the tank 4 for the crude oil of the receiver. In this case, the discharge amount of the naphtha 3 from the inboard tanks 11 can simply and securely be measured, and the timing to change the receiver tank to the tank 6 for the naphtha from the tank 4 for the crude

oil can be obtained with good precision.

Similarly, when the discharge amount of the crude oil 2 is measured (step S18), the discharge amount of the crude oil 2 from the inboard tanks 11 may of course be measured using a fixed scale 62 of the tank 6 for the naphtha of the receiver.

Additionally, since the special partition agent for separating the naphtha 3 and crude oil 2 from each other is not used in the present invention, a boundary of the naphtha 3 and crude oil 2 corresponds to a mixed fluid 7 with the naphtha 3 and crude oil 2 mixed therein.

This mixed fluid 7 is formed in the piping 53 by a distance determined by various conditions. Therefore, when the mixing of the crude oil 2 into the naphtha 3 is prevented, or the mixed amount of the crude oil 2 into the naphtha 3 is controlled, it is necessary to know the state of the mixed fluid 7 in accordance with the discharge amount of the naphtha 3 or crude oil 2.

FIG. 6 shows schematic diagrams of the mixed fluid in the piping in the embodiment of the present invention, (a) shows a sectional view of a state in which the naphtha is discharged into the piping with the crude oil remaining therein, and (b) shows a sectional view of a state in which the crude oil is discharged into the piping with the naphtha remaining therein.

In the drawing (a), when the naphtha 3 is discharged into the piping 53 with the crude oil 2 remaining therein, the mixed fluid 7 having a distance L1 is formed in the

piping 53, and the distance L1 of the mixed fluid 7 depends on the length of the piping (see FIG. 10).

Moreover, a concentration curve indicates a ratio of the naphtha 3 to the crude oil 2 in a section of the piping 53, the naphtha ratio increases toward the tip end of the mixed fluid 7, and the naphtha ratio drops toward a rear end.

Furthermore, in the drawing (b), when the crude oil 2 is discharged into the piping 53 with the naphtha 3 remaining therein, the mixed fluid 7 having a distance L2 is formed in the piping 53, and the distance L2 of the mixed fluid 7 similarly depends on the length of the piping.

Additionally, the concentration curve indicates the ratio of the crude oil 2 to the naphtha 3 in the section of the piping 53, the crude oil ratio decreases toward the tip end of the mixed fluid 7, and the crude oil ratio increases toward the rear end.

Here, in order to minimize the mixture of the crude oil 2 and naphtha 3, it is necessary to execute a flow rate control of the naphtha 3 or crude oil 2 to discharge and a changeover control of the storage tank with good precision.

That is, when the flow rate control (control of the discharge speed) of the naphtha 3 or crude oil 2 to discharge is executed, with the shorter distance of the mixed fluid 7 in the piping 53, the mixed amount of the naphtha 3 and crude oil 2 can be reduced.

Moreover, in the changeover control of the storage

tank, that is, in a control of the timing to stop the discharge of the naphtha 3 or crude oil 2, the state of the mixed fluid 7 being transferred cannot directly be observed, therefore flow states of the crude oil 2, naphtha 3, and mixed fluid 7 in the piping 53 are analyzed, and this flow analysis result is preferably used. In this case, it is possible to control the mixed amount of the crude oil 2 into the naphtha 3 with good precision, and it is also possible to prevent disadvantages that a given ratio of or more heavy compounds are mixed in the naphtha 3 and the naphtha 3 is contaminated by the heavy compounds.

In the fluid analysis, the flow states of the crude oil 2, naphtha 3, and mixed fluid 7 with respect to the discharge flow rate are analyzed from a continuity equation (1), momentum equation (2), turbulence model equation (3), and diffusion equation (4) shown in FIG. 7.

In the drawing, a concentration distribution in the piping 53 can be calculated from the continuity equation (1), momentum equation (2), and diffusion equation (4).

Subsequently, the flow state of the mixed fluid 7 is analyzed, the flow analysis result is used, and the timing to stop the discharge of the naphtha 3 or crude oil 2 from the inboard tanks 11 is determined. In this case, the naphtha or crude oil ratio in an arbitrary position of the piping 53 can be obtained. Therefore, for example, even when a part of the mixed fluid 7 is pushed out into the tanks 4, 6, the crude oil or naphtha amount of the mixed fluid 7 in the piping 53 can be calculated with good

precision.

Moreover, when the crude oil 2 or naphtha 3 remaining in the piping 53 is discharged into the tanks 4 for the crude oil or tanks 6 for the naphtha, the discharge speed of the naphtha 3 or crude oil 2 is changed, and the flow state of the mixed fluid 7 is simulated. Thereby, it is possible to select the discharge speed of the naphtha 3 or crude oil 2 so that the distances L1, L2 of the mixed fluid 7 can be reduced. The crude oil or naphtha can be transferred, while the mixing of the crude oil 2 into the naphtha 3 is minimized.

An analysis example will next be described with reference to the drawings in which the transfer method of the crude oil and naphtha according to the present embodiment, and the piping 53 filled with the crude oil 2 are used to transfer the crude oil 2 and naphtha 3 to the tanks 4 for the crude oil and tanks 6 for the naphtha on land from the inboard tanks 11.

(Analysis Example)

FIG. 8 shows schematic diagrams of the analysis example of the flow state of the present embodiment, (a) shows an analysis model diagram, and (b) shows a graph indicating a change of a discharge speed (flow rate).

In the drawing (a), the piping 53 has an inner diameter of about 1.2 m and a length of about 9 km, the crude oil 2 remains in the piping, and the naphtha 3 is discharged from the pump 12 of the large-sized tanker 1

(not shown).

Moreover, in the drawing (b), for the discharge speed of the naphtha 3, the flow rate is usually increased in proportion to time. As shown by a usual discharge curve, with a predetermined discharge speed (e.g., about 4800 kl/hr), the transfer is continued at the predetermined discharge speed. Before stopping the transfer, the flow rate is reduced similarly and substantially in proportion to time, and the transfer is stopped.

On the other hand, in the transfer method of the crude oil and naphtha according to the present invention, the discharge speed of the naphtha 3 immediately after the discharge start is rapidly raised up to the predetermined discharge speed.

When the discharge speed is rapidly increased immediately after the discharge start of the naphtha 3, in this manner, and a turbulent state is obtained as quickly as possible, the distance of the mixed fluid 7 can be minimized.

That is, when the flow state of the mixed fluid 7 is simulated, and the discharge speed of the naphtha 3 or crude oil 2 is changed immediately after the discharge start, the length of the mixed fluid 7 of the naphtha 3 and crude oil 2 in the piping 53 can be shortened, and the mixing of the naphtha 3 and crude oil 2 in the piping 53 can be minimized.

Additionally, the method of changing the discharge speed of the naphtha 3 or crude oil 2 based on the flow

analysis of the naphtha 3, crude oil 2, and mixed fluid 7 including the crude oil 2 and naphtha 3 in the piping 53 in pushing out the crude oil 2 or naphtha 3 remaining in the piping 53 into the tanks 4, 6 is not limited by the change of the discharge speed, and differs, for example, with disposing conditions of the piping.

Moreover, the discharge speed of the naphtha 3 or crude oil 2 may be changed immediately before the discharge stop. In this case, it is possible to obtain the timing to change the receiver tank to the tank 6 for the naphtha or the tank 4 for the crude oil from the tank 4 for the crude oil or the tank 6 for the naphtha with good precision, and the crude oil 2 can more securely be prevented from being mixed in the naphtha 3.

FIG. 9 is a graph showing the transfer state of the crude oil and naphtha and indicating a transfer amount to a transfer time in the analysis example of the present embodiment.

First, the situation of the present analysis example will be described with reference to the flowchart shown in FIG. 5.

The large-sized tanker 1 is a 300,000 ton class tanker, and carries about 230,000 KL of the crude oil and about 70,000 KL of the naphtha in a plurality of inboard tanks 11 so that the crude oil is not mixed with the naphtha.

Moreover, the crude oil 2 remains in the piping 53 before the transfer start.

When the piping 53 with the crude oil 2 remaining therein is used to transfer the naphtha 3 into the tanks 6 for the naphtha from the inboard tanks 11, the piping 53 is connected to the tanks 4 for the crude oil (step S11).

Subsequently, the amount of the crude oil 2 remaining in the piping 53 which connects the inboard tanks 11 to the tanks 4 for the crude oil is calculated beforehand (step S12).

For the large-sized tanker 1 moored at the sea berth, the inboard tanks 11 loaded with the naphtha 3 are connected to the pump 12 disposed in the large-sized tanker 1, and the pump 12 pushes out the crude oil 2 remaining in the piping 53 into the tanks 4 for the crude oil, so that the naphtha 3 is discharged into the piping 53 from the inboard tanks 11. Subsequently, the discharge amount of the crude oil 2 is measured using the fixed scale 42 of each tank 4 for the crude oil (step S13).

Here, the naphtha 3 is discharged in a discharge curve shown in FIG. 8(b) based on the analysis result.

FIG. 10 is a graph of a concentration curve showing a naphtha concentration distribution of a piping length direction in the analysis example of the present embodiment.

In the drawing, concentration curves A, B, C are naphtha concentration curves in piping lengths. For example, the concentration curve A shows the concentration curve of the naphtha of the mixed fluid 7 extending in a piping length of about 2350 m to 2650 m about 0.6 hour

after the discharge start.

That is, when the naphtha 3 is discharged in the discharge curve, only the crude oil 2 exists in the piping 53 after the piping length of about 2650 m, the crude oil 2 and naphtha 3 exist in the piping 53 extending in a piping length of about 2650 m to 2350 m in accordance with the concentration curve A, and only the naphtha 3 exists in the piping 53 before the piping length of about 2350 m.

Moreover, the mixed fluid 7 has a length of about 300 m in the piping 53, and a naphtha ratio in a middle portion (i.e., a position of the piping length of about 2500 m) is about 40 vol%.

In this case, a reason why the naphtha ratio in the middle portion of the mixed fluid 7 is not about 50 vol% is that the density of the naphtha 3 is smaller than that of the crude oil 2. When the densities of the crude oil 2 and naphtha 3 are measured with good precision, the flow analysis in the piping 53 can be carried out with good precision.

Moreover, the mixed fluid 7 lengthens when transferred in the piping 53. For example, about 1.2 hours after the discharge start, as shown by the concentration curve B, when the tip end of the mixed fluid 7 is in about 5225 m, the rear end is in about 4775 m, and the mixed fluid 7 has a length of about 450 m in the piping 53.

Further with the transfer, for example, about 2.4 hours after the discharge start, as shown by the concentration curve C, when the tip end of the mixed fluid

7 is in the position of about 9365 m, the rear end is in about 8635 m, and the mixed fluid 7 has a length of about 730 m in the piping 53.

When the concentration curve is calculated with the tip end of the mixed fluid 7 reaching the end of the piping 53 in this manner, the crude oil amount in the mixed fluid 7 can be calculated with good precision. Therefore, the crude oil amount obtained by subtracting the crude oil amount in the mixed fluid 7 from the crude oil amount remaining in the piping 53 is pushed out into the tanks 4 for the crude oil, and it can then be known that the tip end of the mixed fluid 7 reaches the end of the piping 53.

That is, it can be known that the tip end of the mixed fluid 7 has reached the end of the piping 53, or will reach the end several seconds after. Moreover, even when the tip end of the mixed fluid 7 is pushed out into the tanks 4 for the crude oil, the length and concentration curve of the mixed fluid 7 remaining in the piping 53 can be obtained from the flow analysis result, and the mixed crude oil amount can be calculated with good precision. Therefore, while the crude oil amount mixed in the naphtha 3 is controlled with remarkably good precision, the crude oil 2 remaining in the piping 53 can be pushed out.

Additionally, to minimize the naphtha 3 to be transferred into the tanks 4 for the crude oil without substantially mixing the crude oil 2 in the naphtha 3 of the tanks 6 for the naphtha, when the rear end of the mixed fluid 7 passes through the piping 53, the discharge of the

naphtha 3 may be stopped.

Moreover, the crude oil amount which can be mixed in the naphtha 3 is set. In this case, since the discharge stop position of the mixed fluid 7 can be calculated from the concentration curve in accordance with the mixed crude oil amount, the mixed amount of the crude oil 2 into the naphtha 3 can be controlled with good precision.

Subsequently, when the discharge amount of the naphtha 3 from the inboard tanks 11 is substantially the same as the pre-calculated amount of the remaining crude oil 2, the discharge of the naphtha 3 from the inboard tanks 11 is stopped, and the receiver tank is changed to the tank 6 for the naphtha from the tank 4 for the crude oil (step S14).

Moreover, after the receiver tank is changed to the tank 6 for the naphtha from tank 4 for the crude oil, the discharge of the naphtha 3 from the inboard tanks 11 is restarted, and the naphtha 3 is stored in the tank 6 for the naphtha (step S15).

Next, the crude oil 2 needs to be transferred. However, in this stage, the naphtha 3 remains in the piping 53.

Therefore, in the same manner as in pushing out the crude oil 2 remaining in the piping 53 by the naphtha 3, this time the naphtha 3 remaining in the piping 53 is pushed out into the tanks 6 for the naphtha by the crude oil 2.

Additionally, the subsequent steps can be carried out

similarly as described above.

That is, to maximize the naphtha 3 to be transferred into the tanks 6 for the naphtha without mixing the crude oil 2 in the naphtha 3 of the tanks 6 for the naphtha, when the tip end of the mixed fluid 7 reaches the end of the piping 53, the discharge of the crude oil 2 may be stopped. Moreover, the crude oil amount which can be mixed in the naphtha 3 is set. In this case, the discharge stop position of the mixed fluid 7 is calculated from the concentration curve in accordance with the mixed crude oil amount, and the discharge of the crude oil 2 may be stopped so that the mixed fluid 7 stops in the stop position.

In the present invention, the calculation of the crude oil remaining in the piping, the comparison of the calculated remaining crude oil amount with the measured crude oil amount, the flow analysis of the mixed fluid, and the like are performed by a control apparatus (not shown).

Additionally, the control apparatus may also use the flow analysis result to automatically control the opening/closing the pump 12 and valves 51, 61. In this case, the mixed amount of the crude oil 2 into the naphtha 3 can be controlled with good precision.

When the valves 51, 61 are of a manual type, an operator opens/closes the valves based on an instruction of the control apparatus.

Moreover, when the amount of the pushed-out crude oil 2 or naphtha 3 is measured by the fixed scale 42 or 62, and the amount of the naphtha 3 or crude oil 2 discharged from

the inboard tanks 11 is calculated from the measurement result, the measurement result is inputted into the control apparatus every predetermined time, and the flow state of the mixed fluid 7 can then be known.

Here, for the timing to input the measurement result into the control apparatus, for example, every time the amount increases by about 1000 kl from about 5000 kl of a quantity indicated by the fixed scale, the measurement result is inputted into the control apparatus. Furthermore, every time the amount increases by about 200 kl from about 1000 kl of the quantity indicated by the fixed scale, the measurement result may be inputted into the control apparatus. In this case, the flow state of the mixed fluid 7 can be known with good precision.

The preferred embodiment of the present invention has been described, but the present invention is not limited to the above-described embodiment.

For example, the present invention can also be applied not only to the VLCC but also to a ULCC as a crude oil tanker much larger than the VLCC or a crude oil tanker smaller than the VLCC.

According to a transfer method of the crude oil and naphtha of the present invention, the crude oil tanker is loaded with both a crude oil lot and naphtha lot, and a sea berth to piping exclusive for the crude oil are used in common. While the mixing of the crude oil and naphtha is minimized, the crude oil and naphtha can separately be

contained in tanks.

That is, even when the naphtha is transferred to a land tank from the crude oil tanker having carried the naphtha via the piping for the crude oil, the mixing of the crude oil into the naphtha (contamination of the naphtha) can be suppressed to be not more than a level usable as material naphtha.

Industrial Applicability

The present invention can also be applied, for example, to a railroad car with a tanker, car, airplane, and the like, in addition to the tanker (ship).

CLAIMS

1. A method of carrying crude oil and naphtha with a common carrier and transferring the crude oil and naphtha to a storage tank from a carrying tank by one piping, comprising the steps of:

(1) using said piping to discharge the naphtha or crude oil to said storage tank from said carrying tank, while said piping is connected to a tank for the crude oil or naphtha;

(2) calculating an amount of the crude oil or naphtha remaining in said piping via which said carrying tank is connected to the storage tank beforehand;

(3) discharging the naphtha or crude oil from said carrying tank, and measuring a discharge amount;

(4) stopping the discharging of the naphtha or crude oil from said carrying tank and changing a receiver tank to the tank for the naphtha or crude oil from the tank for the crude oil or naphtha, when the discharge amount of the naphtha or crude oil from said carrying tank is substantially the same as the pre-calculated amount of the crude oil or naphtha remaining in said piping; and

(5) restarting the discharging of the naphtha or crude oil from said carrying tank after changing said tank, and storing naphtha or the crude oil into the tank for naphtha or the crude oil.

2. The transfer method of the crude oil and naphtha

according to claim 1, further comprising the steps of: analyzing a flow of the crude oil, the naphtha, and a mixed fluid including the crude oil and naphtha in said piping; and using the flow analysis result to determine a timing at which the discharging of the naphtha or crude oil from said carrying tank is stopped.

3. The transfer method of the crude oil and naphtha according to claim 1 or 2 wherein the step of calculating the amount of the crude oil or naphtha remaining in said piping beforehand includes the steps of using at least a temperature, density, or specific gravity of the remaining crude oil or naphtha as a correction element.

4. The transfer method of the crude oil and naphtha according to any one of claims 1 to 3, further comprising the steps of: using a fixed scale of said receiver tank to measure the discharge amount of the naphtha or crude oil from said carrying tank.

5. The transfer method of the crude oil and naphtha according to any one of claims 1 to 4, further comprising the steps of: changing the discharge speed of the naphtha or crude oil based on said flow analysis result, when pushing out the crude oil or naphtha remaining in said piping into the tank.

6. The transfer method of the crude oil and naphtha

according to claim 5, further comprising the steps of: changing the discharge speed of said naphtha or crude oil immediately after starting the discharging of said naphtha or crude oil and immediately before stopping the discharging.

7. The transfer method of the crude oil and naphtha according to claim 6, further comprising the steps of: rapidly raising the discharge speed of said naphtha or crude oil immediately after starting the discharging of said naphtha or crude oil up to a predetermined discharge speed.