

DESCRIPTION

METHOD FOR PREVENTING FOULING OF HEAT EXCHANGER IN
PETROLEUM PROCESS

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Technical Field

[0001] The present disclosure relates to a method for preventing fouling of a heat exchanger in a petroleum process.

10 Background Art

[0002] In a distillation process of a petroleum refining plant for refining crude oil, after crude oil is heated in a heat exchanger and a heating furnace, the crude oil is fed to a distillation tower for distillation operation. Since the crude oil undergoes heat hysteresis in the heat exchanger and the heating furnace, a large amount of fouling
15 adheres to the heat exchanger and the heating furnace. One form of fouling components is a form mixed with an organic polymeric component called asphaltene. Such adhesion of fouling reduces the heat exchanging effectiveness of the heat exchanger and the heating furnace, which increases the fuel use for maintaining an outlet temperature.

20 [0003] Patent Document 1 discloses an antifouling agent and a fouling prevention method for a heat exchanger and a heating furnace, which is added to a process fluid at an upstream of a desalter. Patent Document 2 discloses a method for preventing asphaltene fouling in a preheat exchanger in a petroleum process using a phosphate-based anticorrosive and a dispersant.

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Prior Art Documents

Patent Documents

[0004] Patent Document 1: JP 2010-163539 A

Patent Document 2: WO 2015/022979

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Disclosure of Invention

Problem to be Solved by the Invention

[0005] The present inventors found that the phosphate-based anticorrosive is particularly useful for preventing asphaltene fouling of a preheat exchanger (Patent Document 2). However, the use of phosphate in place of conventional antifouling agents causes corrosion of carbon steel and stainless steel, which are used in general antifouling agent storage tanks and chemical feeders. Particularly, corrosivity of phosphate is notably exhibited as the temperature of phosphate rises. At a high temperature region in a feeding point, the temperature of phosphate climbs up to about 200°C. Since conventional chemical feeders cannot withstand the corrosion by phosphate, the material of the chemical feeders needs to be changed to a corrosion-resistant material.

[0006] In one aspect, the present disclosure provides a new method for preventing fouling of a heat exchanger in a petroleum process.

Means for Solving Problem

[0007] In one aspect, the present disclosure relates to a method for preventing fouling of a heat exchanger in a petroleum process, including adding a phosphite compound and a dispersant to a process fluid that passes through the heat exchanger.

[0008] In another aspect, the present disclosure relates to an antifouling agent for use in the fouling prevention method of the present disclosure, including a phosphite compound and a dispersant.

Effect of the Invention

[0009] The present disclosure can reduce the fouling of the heat exchanger in the petroleum process. In one or more embodiments, the present disclosure can reduce the corrosion of the antifouling agent storage tank and chemical feeder.

Brief Description of Drawings

[0010] [FIG. 1] FIG. 1 is a block diagram illustrating an exemplary petroleum refining process equipment equipped with an atmospheric distillation tower.

[FIG. 2] FIG. 2 is a cross-sectional view of a heat pipe used in a fouling prevention test.

[FIG. 3] FIG. 3 is a cross-sectional view illustrating a state in which the heat

pipe is inserted into a heat pipe holder.

Description of the Invention

[0011] The present disclosure is based on a finding that a combined use of a
5 phosphite compound (a phosphite ester compound) and a dispersant can prevent
fouling of a heat exchanger such as a preheat exchanger in a petroleum process.
Further, the present disclosure is based on a finding that the use of the phosphite
compound instead of the phosphate-based anticorrosive can reduce corrosion of a
chemical feeder, which is caused in the case of using the phosphate-based anticorrosive
10 as an antifouling agent.

[0012] In one or more embodiments, the present disclosure can prevent fouling of a
heat exchanger such as a preheat exchange in a petroleum process, and preferably
improve and maintain the heat exchanging effectiveness of the heat exchanger and
reduce the fuel cost and the cleaning cost. In one or more embodiments, the present
15 disclosure can prevent fouling of a heat exchanger in a petroleum process even using a
conventional chemical feeder, i.e., without the necessity of modifying the chemical
feeder.

[0013] It is not clear in detail why the fouling prevention method of the present
disclosure can prevent fouling of a heat exchanger, in particular a preheat exchanger,
20 but the mechanism is considered as follows. As one of the causes of fouling, sulfur
atoms of asphaltene form sulfides on the surface of the heat exchanger, and the
sulfides deposit thereon. When a phosphite compound and a dispersant are added, a
coating of the phosphite compound and/or the phosphite compound decomposed under
high temperature is formed on the surface of the heat exchanger, and the coating
25 restrains the formation of sulfides on the surface of the heat exchanger. The present
disclosure, however, is not limited to this mechanism.

[0014] The term "petroleum process" in the present disclosure refers to the whole or a
part of a process of producing various petroleum products using hydrocarbons of crude
oil or the like as a starting material. In one or more embodiments, the petroleum
30 process may include at least: heating hydrocarbons of crude oil or the like; and
separating the heated hydrocarbons into various components such as LPG, gasoline
(e.g., naphtha) and light oil by utilizing the difference in the boiling point of

hydrocarbons in an atmospheric distillation device. In one or more embodiments, the petroleum process in the present disclosure may include a petroleum refining process.

[0015] The "heat exchanger" in the fouling prevention method of the present disclosure is a heat exchanger to be used in the petroleum process. In one or more
5 non-limiting embodiments, the heat exchanger include a preheat exchanger (also called a preliminary heat exchanger or a preheat heat exchanger), a preheater, and a reboiler. In these heat exchangers, a region where fouling is particularly easily generated and accumulates is a high-temperature region of about 200°C or higher. In one or more embodiments, the fouling prevention method of the present disclosure is a
10 fouling prevention method for a heat exchanger that includes the high-temperature region reaching a temperature of about 200°C, for example, 180°C or higher, 190°C or higher, 200°C or higher, 210°C or higher, or 220°C or higher, during operation. In one or more embodiments, the fouling prevention method of the present disclosure can exhibit a fouling prevention effect more effectively at a temperature of about 200°C or
15 higher.

In one or more embodiments, the heat exchanger in the petroleum process is a heat exchanger in the petroleum refining process, or a preheat exchanger in the petroleum process.

[0016] The term "process fluid" in the present disclosure refers to a liquid or gas to be
20 used in the petroleum process. In one or more embodiments, the process fluid may be, e.g., crude oil or hydrocarbons derived therefrom to be treated in the petroleum process. In one or more not particularly limiting embodiments, the process fluid may, e.g., a liquid to be supplied to the preheat exchanger in the petroleum refining process, or a liquid inside the preheat exchanger.

[0017] In one or more non-limiting embodiments, the term "fouling" in the fouling prevention method of the present disclosure refers to fouling containing asphaltene, or fouling containing asphaltene that adheres and/or accumulates inside the heat exchanger. Therefore, in one or more embodiments, the fouling prevention in the heat exchanger in the present disclosure includes restraining adhesion and/or
30 accumulation of asphaltene inside the heat exchanger.

[0018] [Fouling Prevention Method]

In one aspect, the present disclosure relates to a method for preventing fouling

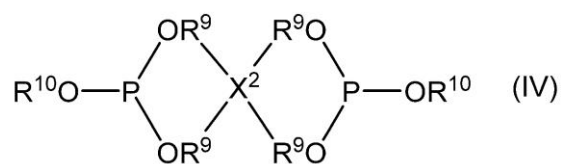
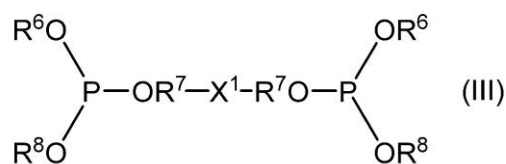
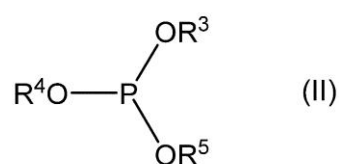
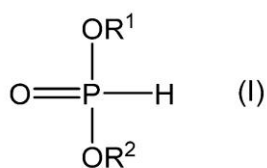
of a heat exchanger in a petroleum process (the fouling prevention method of the present disclosure), including adding a phosphite compound and a dispersant to a process fluid that passes through the heat exchanger in the petroleum process.

[0019] [Phosphite Compound]

5 In one or more embodiments, the phosphite compound to be used in the fouling prevention method of the present disclosure may be, e.g., a phosphite compound to be used in the petroleum process.

[0020] In one or more not particularly limiting embodiments, examples of the phosphite compound include a phosphonic acid type phosphite compound, a phosphorous acid type phosphite compound, and a diphosphite type phosphite compound. The phosphonic acid type phosphite compound may be, e.g., a phosphite compound represented by Formula (I). The phosphorous acid type phosphite compound may be, e.g., a phosphite compound represented by Formula (II). The diphosphite type phosphite compound may be, in one or more embodiments, a compound containing two of the structure of Formula (II) or a dimer of the compound of Formula (II) (a dimerized compound of Formula (II)). The diphosphite type phosphite compound may be, in one or more embodiments, a compound represented by Formula (III) or (IV).

[Chemical Formula 1]



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[0021] In Formula (I), R¹ and R² are the same or different and represent a group having 1 to 30 carbon atoms. In Formula (II), R³, R⁴ and R⁵ are the same or different and represent a group having 1 to 30 carbon atoms. In Formula (III), R⁶, R⁷ and R⁸ are the same or different and represent a group having 1 to 30 carbon atoms, and X¹ is an oxygen atom or a carbon atom. In Formula (IV), R⁹ and R¹⁰ are the same or different and represent a group having 1 to 30 carbon atoms, and X² is a carbon atom.

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In one or more embodiments, examples of the group having 1 to 30 carbon atoms include an alkyl group having a carbon number of 1 to 30, an alkenyl group having a carbon number of 1 to 30, an aryl group having a carbon number of 6 to 30, an aralkyl group having a carbon number of 7 to 30, and an alkylaryl group having a carbon number of 7 to 30. In one or more embodiments, the alkyl group, alkenyl group, aryl group, aralkyl group, and alkylaryl group may have a substituent(s). In one or more embodiments, the alkyl group may be a linear alkyl group or a branched alkyl group.

[0022] In Formula (I), R^1 and R^2 may be the same or different, but preferably R^1 and R^2 are the same. In Formula (II), R^3 , R^4 and R^5 may be the same or different, but preferably R^3 , R^4 and R^5 are the same. In Formula (III), R^6 and R^8 may be the same or different, but preferably R^6 and R^8 are the same.

[0023] In one or more embodiments, examples of the phosphite compound include:

triphenyl phosphite, trisnonylphenyl phosphite, tricresyl phosphite, triethyl phosphite, tris(2-ethylhexyl) phosphite, tridecyl phosphite, trilauryl phosphite, tris(tridecyl) phosphite, trioleyl phosphite, tristearyl phosphite, diphenyl mono(2-ethylhexyl) phosphite, diphenyl monodecyl phosphite, diphenyl mono(tridecyl) phosphite, tris(2,4-di-tert-butylphenyl) phosphite;

diethyl hydrogen phosphite, bis(2-ethylhexyl) hydrogen phosphite, dilauryl hydrogen phosphite, dioleyl hydrogen phosphite, diphenyl hydrogen phosphite;

tetraphenyl dipropylene glycol diphosphite, tetra(C₁₂₋₁₅ alkyl)-4,4'-isopropylidene diphenyl diphosphite, a mixture of bis(tridecyl) pentaerythritol diphosphite and bis(nonylphenyl) pentaerythritol diphosphite, bis(tridecyl) pentaerythritol diphosphite, bis(decyl) pentaerythritol diphosphite, distearyl pentaerythritol diphosphite;

tetraphenyl (tetra(tridecyl) pentaerythritol tetraphosphite, a hydrogenated bisphenol A - pentaerythritol phosphite polymer; and

combinations of these.

[0024] In one or more embodiments, from the viewpoint of further preventing fouling of the heat exchanger in the petroleum process and/or further reducing the corrosion of the storage tank and the chemical feeder, the phosphite compound is preferably

triphenyl phosphite, trisnonylphenyl phosphite, tricresyl phosphite, triethyl phosphite, tris(2-ethylhexyl) phosphite, tridecyl phosphite, trilauryl phosphite, tris(tridecyl) phosphite, trioleyl phosphite, tristearyl phosphite, diphenyl mono(2-ethylhexyl) phosphite, diphenyl monodecyl phosphite, diphenyl mono(tridecyl) phosphite,
 5 tris(2,4-di-tert-butylphenyl) phosphite, diethyl hydrogen phosphite, bis(2-ethylhexyl) hydrogen phosphite, dilauryl hydrogen phosphite, dioleyl hydrogen phosphite, diphenyl hydrogen phosphite, or a combination of these. From the same viewpoint, the phosphite compound is preferably a phosphonic acid type phosphite compound, and more preferably diethyl hydrogen phosphite, bis(2-ethylhexyl) hydrogen
 10 phosphite, dilauryl hydrogen phosphite, dioleyl hydrogen phosphite, diphenyl hydrogen phosphite, or a combination of these.

[0025] In one or more embodiments, the phosphite compound may be used individually or in combination of two or more kinds.

[0026] In one or more embodiments, the concentration of the phosphite compound in
 15 the process fluid to be supplied to the heat exchanger is 1 to 100 ppm, 2 to 80 ppm, or 3 to 50 ppm. In one or more embodiments, the fouling prevention method of the present disclosure includes adding phosphite to the process fluid so that the concentration of the phosphite in the process fluid to be supplied to the heat exchanger is 1 to 100 ppm, 2 to 80 ppm, or 3 to 50 ppm.

20 [0027] [Dispersant]

The dispersant usable in the fouling prevention method of the present disclosure may be, e.g., a dispersant that has been conventionally used to prevent fouling in the petroleum process or fouling of the heat exchanger in the petroleum process, or a dispersant usable in the future. In one or more non-limiting
 25 embodiments, the dispersant usable in the fouling prevention method of the present disclosure may be, e.g., polyolefin ester, polyalkenyl-substituted succinate, or a combination of these.

[0028] In one or more embodiments, the concentration of the dispersant in the process fluid to be supplied to the heat exchanger is 1 to 100 ppm, 2 to 80 ppm, or 3 to
 30 50 ppm. In one or more embodiments, the fouling prevention method of the present disclosure includes adding the dispersant to the process fluid so that the concentration of the dispersant in the process fluid to be supplied to the heat exchanger is 1 to 100

ppm, 2 to 80 ppm, or 3 to 50 ppm.

[0029] In one or more embodiments, a ratio of the content (ppm) of the phosphite compound and the content (ppm) of the dispersant in the process fluid to be supplied to the heat exchanger is 5:1 to 1:5, 3:1 to 1:3, or 2:1 to 1:2. In one or more embodiments, the fouling prevention method of the present disclosure includes adding the phosphite compound and the dispersant to the process fluid so that the ratio of the content (ppm) of the phosphite compound and the content (ppm) of the dispersant in the process fluid to be supplied to the heat exchanger is 5:1 to 1:5, 3:1 to 1:3, or 2:1 to 1:2.

[0030] A site at which the phosphite compound and the dispersant are added to the process fluid is not particularly limited, and in one or more embodiments, it may be, e.g., a site at which the phosphite compound and the dispersant with the above concentrations can be introduced in a heat exchanger that is a target of fouling prevention, or a site positioned upstream of the target heat exchanger. The order of the addition of the phosphite compound and the dispersant is not particularly limited.

In one or more embodiments, the two may be added simultaneously or separately, or may be added at different sites.

[0031] FIG. 1 is a block diagram illustrating an exemplary petroleum refining process equipment equipped with an atmospheric distillation tower. In the petroleum refining process equipment, crude oil supplied via a pump 6 is desalted in a desalter 1, and then heated in a preheat exchanger 2 (heat exchanger 2) to 150 to 180°C, introduced into a preheat exchanger 3 (heat exchanger 3) to be heated to 240 to 280°C, heated in a heating furnace 4 to 350 to 380°C, and then introduced into an atmospheric distillation tower 5. A bottom product is sent as a heat source from the bottom of the atmospheric distillation tower 5 to the heat exchangers 3 and 2 via a pump 7.

[0032] In a case of employing the fouling prevention method of the present disclosure in the heat exchanger 3 of the petroleum process of FIG. 1, the site at which the phosphite compound and the dispersant are added may be, in one or more non-limiting embodiments, a site indicated by an arrow A in FIG. 1, which is upstream of the heat exchanger 3, or may be a site indicated by an arrow C, which is further upstream of the heat exchanger 3. In a case of employing the fouling prevention method of the present disclosure on the heating side in the heat exchanger 3 of FIG. 1,

the site at which the phosphite compound and the dispersant are added may be, in one or more non-limiting embodiments, a site indicated by an arrow B in FIG. 1, which is upstream of the heat exchanger 3.

[0033] [Antifouling Agent]

5 In one aspect, the present disclosure relates to an antifouling agent for use in the fouling prevention method of the present disclosure, the antifouling agent including a phosphite compound and a dispersant. In one or more embodiments, the form of the antifouling agent of this aspect may be a solid such as powder or a tablet, or in a state of being dissolved in a solvent, i.e., a concentrated liquid form.

10 [0034] [Use]

In one aspect, the present disclosure relates to the use of the phosphite compound in the fouling prevention method of the present disclosure. In another aspect, the present disclosure relates to the use of the phosphite compound for preventing fouling of the heat exchanger of the petroleum process through which the process fluid containing the dispersant passes. The phosphite compound is as described above.

[0035] The present disclosure may relate to the following one or more embodiments.

[1] A method for preventing fouling of a heat exchanger in a petroleum process, including adding a phosphite compound and a dispersant to a process fluid that passes through the heat exchanger.

[2] The method according to [1], including adding the phosphite compound to the process fluid so that a concentration of the phosphite compound in the process fluid to be supplied to the heat exchanger is 1 to 100 ppm.

[3] The method according to [1] or [2], including adding the dispersant to the process fluid so that a concentration of the dispersant in the process fluid to be supplied to the heat exchanger is 1 to 100 ppm.

[4] The method according to any of [1] to [3], including adding the phosphite compound and the dispersant to the process fluid so that a ratio of a content (ppm) of the phosphite compound and a content (ppm) of the dispersant (phosphite compound : dispersant) in the process fluid to be supplied to the heat exchanger is 5:1 to 1:5.

[5] The method according to any of [1] to [4], wherein the fouling prevention includes restraining adhesion and/or accumulation of asphaltene inside the heat

exchanger.

[6] An antifouling agent for use in the method according to any of [1] to [5], including a phosphite compound and a dispersant.

[7] Use of a phosphite compound for preventing fouling of a heat exchanger in a
5 petroleum process through which a process fluid with an added dispersant passes.

[0036] The present disclosure will be described by way of examples and comparative examples below. However, the present disclosure is not limited thereto.

Examples

10 [0037] [Test Pieces]

The following two kinds of test pieces were prepared.

Carbon steel: 10 mm × 60 mm × 1 mm, SPCC, 7.85 g/cm³

Stainless steel: 10 mm × 60 mm × 1 mm, SUS 304, 7.93 g/cm³

[0038] [Agents]

15 The following agents were prepared.

Phosphite composition A: containing a phosphite A (phosphonic acid type phosphite compound) and a dispersant

Phosphite composition B: containing a phosphite B (phosphonic acid type phosphite compound) and a dispersant

20 Phosphite composition C: containing a phosphite C (phosphorous acid type phosphite compound) and a dispersant

Phosphite composition D: containing a phosphite D (phosphorous acid type phosphite compound) and a dispersant

25 Phosphite composition E: containing the phosphite A (phosphonic acid type phosphite compound), the phosphite C (phosphorous acid type phosphite compound) and a dispersant

Phosphate composition: containing a phosphate used as an anticorrosive for high-temperature application and a dispersant

30 The phosphite A, the phosphite B, the phosphite C and the phosphite D are all different phosphite compounds. Polyolefin ester was used as the dispersant.

<Preparation Method of Compositions>

The compositions A-D were prepared using heavy aromatic naphtha as a

solvent so that the content of the phosphite or phosphate and the content of the dispersant would be each 30% by weight, i.e., in the ratio (weight ratio) of 1:1. The phosphite composition E was prepared so that the content of the mixture containing equivalent amounts of the phosphite A and the phosphite C and the content of the dispersant would be each 30% by weight, i.e., in the ratio (weight ratio) of 1:1.

[0039] [Anticorrosive Effect Confirmation Test 1]

Each agent was subjected to an anticorrosive effect confirmation test in accordance with the following procedure using the carbon steel test piece. First, 100 ml of the agent of Table 1 was poured into a 100 ml screw cap tube. The test piece that had been weighed (weight before test) after acetone defatting and drying was placed in the screw cap tube. The tube was then capped and left to stand for seven days in a thermostat at 50°C.

[0040] [Evaluation]

After the test, the test piece was collected, and rust thereon was removed with 15% hydrochloric acid aqueous solution and tap water. A corrosion rate (MDD) and an erosion rate (mm/y) were calculated from a difference in the weight of the test piece before and after the test using the following formulae.

$$\text{Corrosion rate (MDD)} = (M_1 - M_2) / (S \times T)$$

$$\text{Erosion rate (mm/y)} = \text{MDD} \times \{365 \times 10^{-4}\} / d$$

M_1 : mass of test piece before test (mg)

M_2 : mass of test piece after test (mg)

S: surface area (dm²) of test piece

T: the number of days of test

d: density (g/cm³) of test piece

[0041]

(Table 1)	Agent	MDD	mm/y
Comparative Example 1	Phosphate composition	59.8	0.28
Example 1	Phosphite composition A	<1.0	<0.01
Example 2	Phosphite composition B	<1.0	<0.01
Example 3	Phosphite composition C	<1.0	<0.01
Example 4	Phosphite composition D	<1.0	<0.01
Example 5	Phosphite composition E	<1.0	<0.01

[0042] As shown in Table 1, Comparative Example 1 using the phosphate composition caused corrosion of the carbon steel. On the other hand, corrosion of the

carbon steel was not observed in Examples 1-5 using the phosphite compositions.

[0043] [Anticorrosive Effect Confirmation Test 2]

Each composition was subjected to an anticorrosive effect confirmation test in accordance with the following procedure using the stainless steel test piece.

5 To conduct the test at 150°C, an oxidation stability test machine, a cylinder set and a test container set that are described in the oxidation stability test method of JIS K 2276 (Petroleum Products-Testing Methods for Aviation Fuels) were used. First, 100 ml of the agent below was poured into the test container made of glass. The test piece that had been weighed (weight before test) after acetone defatting and drying
10 was placed in the test container. The container was covered and placed in the cylinder. An operation of injecting nitrogen into the cylinder at 0.5 MPa and releasing was repeated three times to replace oxygen inside the cylinder with nitrogen. In the third time, the cylinder was sealed, with nitrogen injected in the cylinder. The cylinder after nitrogen substitution was placed in the oxidation stability test machine
15 and left to stand for three days in a thermostat at 150°C. After the test, the same evaluation as that in the anticorrosive effect confirmation test 1 was conducted. Table 2 below shows the results.

[0044]

(Table 2)	Agent	MDD	mm/y
Comparative Example 2	Phosphate composition	285.2	1.32
Example 6	Phosphite composition A	<1.0	<0.01
Example 7	Phosphite composition B	<1.0	<0.01
Example 8	Phosphite composition C	<1.0	<0.01
Example 9	Phosphite composition D	<1.0	<0.01
Example 10	Phosphite composition E	<1.0	<0.01

[0045] As shown in Table 2, Comparative Example 2 using the phosphate
20 composition caused corrosion of the stainless steel. On the other hand, corrosion of the stainless steel was not observed in Examples 6-10 using the phosphite compositions.

[0046] <Fouling Prevention Test>

The fouling prevention test is carried out to examine a fouling prevention
25 effect of an antifouling agent for petroleum refining. A heat pipe (heat rod) 21 illustrated in FIG. 2 is used as a test member to which fouling adheres, and the test is conducted by bringing the heat pipe into contact with an oil and measuring a fouling

adhesion state on the pipe. The heat pipe 21 is used in a thermal stability test machine specified in JIS K 2276. The heat pipe 21 is made of soft steel and has a tubular, hourglass shape with ends 21a and 21b having a large diameter and a middle 21c having a small diameter. The heat pipe 21 is inserted into a tubular heat pipe holder 22 illustrated in FIG. 3. An inflow tube 23a and an outflow tube 23b are connected to the upper and lower parts of the heat pipe holder 22, and a thermocouple 24 is inserted in the center of the heat pipe 21. A temperature adjustor not illustrated enables electric current to flow from both the ends 21a and 21b of the heat pipe 21 so that the temperature to be detected by the thermocouple 24 is adjusted to a predetermined temperature. The test apparatus used was an Alcor Hot Liquid Process Simulator equipped with the above-described heat pipe 21.

[0047] The heat pipe 21 was heated by the test apparatus under conditions described below, and each sample was introduced from the inflow tube 23a to conduct the test.

Sample: each sample was prepared by adding the agent of Table 3 below to a crude oil sample so that the concentration of the dispersant and the concentration of the phosphite or phosphate compound would be each 10 ppm with respect to the crude oil sample.

Heat pipe 21 temperature: 360°C (heated to 360°C over 20 minutes);

Tank, line and pump temperatures: 100°C;

Sample volume: 500 ml (tank is partitioned, so that the sample is not mixed with returned sample);

Sample introducing flow rate: 1 ml/minute;

In-system pressure: 500 psi (pressure adjusted with nitrogen)

Test period: 5 hours

[0048] The fouling prevention effect was evaluated based on the change in the outlet temperature of sample (Δt) under the following evaluation criteria. Table 3 below shows the results.

[Change in Outlet Temperature of Sample: Δt]

A change in the sample temperature (Δt) at the outflow tube 23b (an outlet of the heating section) was measured by comparing a sample temperature at which the sample reached the highest temperature after the start of the test and a sample temperature after a lapse of five hours. A larger value of Δt indicates a larger amount

of fouling adhering on the heat pipe²¹.

Evaluation criteria A: Δt is less than 8
 B: Δt is 8 or more and less than 15
 C: Δt is 15 or more

5 [0049]

(Table 3)	Agent	Evaluation
Blank	—	C
Reference Example 1	Phosphate composition	A
Example 11	Phosphite composition A	A
Example 12	Phosphite composition C	A

[0050] As shown in Table 3, Examples 11 and 12 using the phosphite compositions reduced the adhesion of fouling at a level equivalent to that of Reference Example 1 using the phosphate composition. The test confirmed that the combined use of phosphite and the dispersant can sufficiently prevent the fouling of the heat exchanger

10 in the petroleum process.

CLAIMS

1. A method for preventing fouling of a heat exchanger in a petroleum process, comprising adding a phosphite compound and a dispersant to a process fluid that
5 passes through the heat exchanger.
2. The method according to claim 1, comprising adding the phosphite compound to the process fluid so that a concentration of the phosphite compound in the process fluid to be supplied to the heat exchanger is 1 to 100 ppm.
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3. The method according to claim 1 or 2, comprising adding the dispersant to the process fluid so that a concentration of the dispersant in the process fluid to be supplied to the heat exchanger is 1 to 100 ppm.
- 15 4. The method according to any of claims 1 to 3, comprising adding the phosphite compound and the dispersant to the process fluid so that a ratio of a content (ppm) of the phosphite compound and a content (ppm) of the dispersant in the process fluid to be supplied to the heat exchanger is 5:1 to 1:5.
- 20 5. The method according to any of claims 1 to 4, wherein the fouling prevention comprises restraining adhesion and/or accumulation of asphaltene inside the heat exchanger.
6. An antifouling agent for use in the method according to any of claims 1 to 5,
25 comprising a phosphite compound and a dispersant.
7. Use of a phosphite compound for preventing fouling of a heat exchanger in a petroleum process through which a process fluid with an added dispersant passes.