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(54) Title: METHOD FOR REDUCING THE AMOUNT OF SULFUR PICK-UP BY HYDROCARBON STREAMS TRANSPORTED THROUGH A PIPELINE

(57) Abrégé/Abstract:
A process for reducing the level of elemental sulfur and organic sulfur pickup by refined hydrocarbon streams such as gasoline, diesel, jet fuel, kerosene or fuel additives such as ethers or iso-octane that are transported through a pipeline used to transport various sulfur-containing petroleum streams. The oxygen level in the hydrocarbon stream of interest to be pipelined as well as in at least the first hydrocarbon stream sequenced immediately ahead of the hydrocarbon stream of interest is reduced.

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(54) Title: METHOD FOR REDUCING THE AMOUNT OF SULFUR PICK-UP BY HYDROCARBON STREAMS TRANSPORTED THROUGH A PIPELINE

(57) Abstract: A process for reducing the level of elemental sulfur and organic sulfur pickup by refined hydrocarbon streams such as gasoline, diesel, jet fuel, kerosene or fuel additives such as ethers or iso-octane that are transported through a pipeline used to transport various sulfur-containing petroleum streams. The oxygen level in the hydrocarbon stream of interest to be pipelined as well as in at least the first hydrocarbon stream sequenced immediately ahead of the hydrocarbon stream of interest is reduced.

METHOD FOR REDUCING THE AMOUNT OF SULFUR PICK-UP BY HYDROCARBON STREAMS TRANSPORTED THROUGH A PIPELINE

FIELD OF THE INVENTION

[0001] This invention relates to a process for reducing the level of elemental sulfur and organic sulfur pick-up by refined hydrocarbon streams such as gasoline, diesel, jet fuel, kerosene or fuel additives such as ethers or iso-octane that are transported through a pipeline used to transport various sulfur-containing petroleum streams. The interior wall of the pipeline is pretreated with a hydrocarbon fluid containing an effective amount of a lubricity agent, such as a carboxylic acid or carboxylic acid derivative containing an amine, alkanol amide, alcohol, polyol or sulphonate, and mixtures thereof.

BACKGROUND OF THE INVENTION

[0002] It is well known that elemental sulfur in hydrocarbon streams, such as petroleum streams, is corrosive and damaging to metal equipment, particularly to copper and copper alloys. Sulfur and sulfur compounds may be present in varying concentrations in refined petroleum streams, such as in gasoline and distillate boiling range streams. Additional contamination will typically take place as a consequence of transporting the refined stream through pipelines that contain sulfur contaminants remaining in the pipeline from the transportation of sour hydrocarbon streams, such as petroleum crudes. The sulfur has a particularly corrosive effect on equipment, such as brass valves, gauges and in-tank fuel pump copper commutators.

[0003] The total sulfur in gasoline after 2005 will be limited to less than 30 wppm, while the total sulfur in diesel after 2006 will be limited to a maximum of 15 wppm. Elemental and organic sulfur contaminants that are picked up in the pipeline by gasoline and diesel products will adversely affect their ability to meet the ultra low sulfur specifications. Organic sulfur pick-up is any non-elemental sulfur component in the hydrocarbon stream that was not present in the hydrocarbon product stream prior to injecting it into the pipeline.

[0004] Various techniques have been reported for removing elemental sulfur from petroleum products. For example, U.S. Patent No. 4,149,966 discloses a method for removing elemental sulfur from refined hydrocarbon fuels by adding an organo-mercaptan compound plus a copper compound capable of forming a soluble complex with the mercaptan and sulfur and contacting the fuel with an adsorbent material to remove the resulting copper complex and substantially all elemental sulfur.

[0005] U.S. Patent No. 4,011,882 discloses a method for reducing sulfur contamination of refined hydrocarbon fluids transported in a pipeline for the transportation of sweet and sour hydrocarbon fluids by washing the pipeline with a wash solution containing a mixture of light and heavy amines, a corrosion inhibitor, a surfactant and an alkanol containing from 1 to 6 carbon atoms.

[0006] U.S. Patent No. 5,618,408 teaches a method for reducing the amount of sulfur and other sulfur contaminants picked up by refined hydrocarbon products, such as gasoline and distillate fuels, which are pipelined in a pipeline used to transport heavier sour hydrocarbon streams. The method involves controlling the level of dissolved oxygen in the refined hydrocarbon stream that is to be pipelined.

[0007] The removal of elemental sulfur from pipelined fuels is also addressed in U.S. Patent No. 5,250,181, which teaches the use of an aqueous solution containing a caustic, an aliphatic mercaptan, and optionally a sulfide to produce an aqueous layer containing metal polysulfides and a clear fluid layer having a reduced elemental sulfur level. Further, U.S. Patent No. 5,199,978 teaches the use of an inorganic caustic material, an alkyl alcohol, and an organo mercaptan, or sulfide compound, capable of reacting with sulfur to form a fluid-insoluble polysulfide salt reaction product at ambient temperatures.

[0008] While such methods have varying degrees of success, there still exists a need in the art for reducing elemental and organic sulfur pick-up by hydrocarbon products when transported in pipelines. Reducing the elemental and organic sulfur pick-up by hydrocarbon products can either eliminate the processing requirements after the pipeline or reduce the operating cost of these processes.

SUMMARY OF THE INVENTION

[0009] In an embodiment, there is provided a process for reducing the level of sulfur pick-up in a hydrocarbon stream of interest being transported in a pipeline that is used to transport various sulfur-containing petroleum streams, which process comprises pretreating the inner wall of the pipeline with a hydrocarbon fluid containing an effective amount of a lubricity agent selected from the group consisting of carboxylic acids and carboxylic acid derivatives containing one or more groups selected from the group consisting of amine, alkanol amide, alcohol, polyol, and sulphonate.

[0010] In another embodiment, the carboxylic acid is a fatty acid or a fatty acid derivative containing a group selected from the group consisting of amine, an alkanolamide, or esters of fatty acids containing an alcohol or polyol group.

[0011] In yet another embodiment, the hydrocarbon fluid is a distillate stream.

[0012] In still another embodiment, the effective amount of lubricity agent is from 100 wppm to 10,000 wppm lubricity agent in hydrocarbon fluid.

DETAILED DESCRIPTION OF THE INVENTION

[0013] Pipelines that are treated in accordance with the present invention are those that are used to transport a variety of sulfur-containing petroleum and chemical streams. Such pipelines are often used to transport crudes and other heavy petroleum feedstreams containing relatively large amounts of sulfur moieties that can contaminate the inner walls of the pipeline. Lower sulfur level streams such as gasolines and diesels will have a tendency to pick up undesirable amounts of sulfur from the sulfur-contaminated walls of the pipeline unless the walls of pipeline are protected to prevent sulfur moieties from adhering to the inner walls of the pipeline.

[0014] The inner walls of the pipeline are pretreated in accordance with the present invention with a hydrocarbon fluid containing low levels of sulfur and also containing an effective amount of at least one lubricity agent. The hydrocarbon fluid is preferably one that is to be normally transported through the pipeline. Preferred hydrocarbon fluids to be used as a carrier to deliver the lubricity agent are gasoline and diesel fuels containing less than 50 wppm sulfur, preferably less than 30 wppm sulfur. Most preferred are diesel fuels since the lubricity agent will be more compatible with such fuels and there will be no need to separate the lubricity agent from the diesel fuel after it reaches its destination point in the pipeline.

[0015] The lubricity agent used in the practice of the present invention is selected from those that when applied to the inner wall of the pipeline will result in a wear-scar diameter, as measured by the HFRR test (ASTM D6079) of less than 500 μm in a low sulfur diesel fuel. It is preferred that the lubricity agent be selected from carboxylic acids and carboxylic acid derivatives containing one or more chemical groups selected from the group consisting of amine, alkanol amine, alcohol, polyol, and sulphonate. It is more preferred that the carboxylic acid be a fatty acid or a fatty acid derivative containing one or more groups selected from amine, alkanolamine, and esters of fatty acids containing an alcohol or polyol group.

[0016] Non-limiting examples of carboxylic acids that can be used in the practice of the present invention include fatty acids with carbon numbers ranging from C_{14} to C_{40}, preferably from C_{16} to C_{30}, and more preferably from C_{16} to C_{20}. Non-limiting examples of the more preferred fatty acids are oleic acid, linoleic acid, and a mixture thereof. Also, preferred are unsaturated oleic acid linoleic acid, and more preferred are amine derivatives of unsaturated oleic and linoleic acid or combinations thereof.

[0017] It is within the scope of this invention that more that one lubricity agent be used. The total amount of lubricity agent used in the hydrocarbon fluid used as a carrier to treat the inner wall of the pipeline will be an effective amount. By "effective amount" we mean that minimum amount needed to form a protective coating on the inner wall of the pipeline to prevent sulfur moieties from adhering thereto. This effective amount will vary depending on whether the pipeline is a virgin pipeline or whether it is a pipeline that was already on stream. A virgin pipeline is expected to require more lubricity agent than a previously treated pipeline that merely needs a maintenance dose. The amount of lubricity agent needed for a virgin pipeline will typically be from 100 wppm to 10,000 wppm, preferably from 1000 wppm to 10,000 wppm in hydrocarbon fluid. The amount of lubricity agent needed to treat a previously-treated pipeline will typically be from 10 wppm to 1000 wppm, preferably from 50 wppm to 500 wppm.

[0018] While it is preferred to use diesel fuels as the hydrocarbon carrier for the lubricity agent, other hydrocarbon streams can also be used. Non-limiting examples of such other hydrocarbon streams that can be used include gasoline, diesel fuel, kerosene and dialkyl ethers. Alkyl ethers and iso-octane are typically used to improve the octane rating of gasoline. These ethers are typically dialkyl ethers having 1 to 7 carbon atoms in each alkyl group. Illustrative ethers are methyl tertiary-butyl ether, methyl tertiary-amyl ether, methyl tertiary-hexyl ether, ethyl tertiary-butyl ether, n-propyl tertiary-butyl ether, and isopropyl tertiary-amyl ether. Mixtures of these ethers and hydrocarbon streams may also be treated in accordance with this invention. Preferred are refined hydrocarbon streams, particularly those wherein the elemental and organic sulfur pick-up is detrimental to the performance of the intended use of the hydrocarbon stream. Diesel streams are preferred since the lubricity agent in more compatible with such streams and will not have to be removed after transporting the stream through the pipeline. It is within the scope of this invention that a small maintenance dose of lubricity agent can be added to all hydrocarbon streams transported through the pipeline, preferably all distillate streams.

[0019] The following examples are illustrative of the invention and are not to be taken as limiting in any way.

EXAMPLES

EXAMPLE 1

[0020] A 5% H_2S in N_2 mixture was bubbled through two litres of crude at 4 ft^3/hr for approximately 0.5 hrs in order to replace any H_2S that may have evolved from the original crude sample. The H_2S/crude mixture was then recycled overnight at 10 cc/min and at 20°C through a 0.75" OD x 18" long column of iron filings (about 40 mesh) to simulate the crude cycle in a pipeline. After crude recirculation the column was subjected to a series of refined products to simulate the product cycle in a pipeline. All products were pre-purged with an O_2/ N_2 mixture

(10%/90%) to simulate typical oxygen levels found in refined products stored in tankage. The products were pumped through the column of iron filings on a once-through basis at 20 cc/min. The following product cycle was tested: 1) 740 cc of low sulfur gasoline initially containing 1.7 mg/l total sulfur and 0 mg/l of S°, and 2) 740 cc of ultra low sulfur diesel (ULSD) initially containing 0.5 mg/l total sulfur and 0 mg/l of S°. Following the product cycle, the column of iron filings was flushed with 300 cc of sulfur-free toluene (air-purged) to remove residual sulfur compounds from the iron filings. The total sulfur content in the products exiting the column was determined by ASTM D5453. The S° content in the products exiting the column was determined by HPLC. The total sulfur pick-up by the products was determined by the subtracting the total sulfur content in the products exiting the column minus the original total sulfur content. The S° pick-up was determined in a similar fashion. The organic sulfur pick-up by the products was determined by subtracting the total sulfur pick-up minus the S° pick-up.

EXAMPLE 2

[0021] The column of iron filings in Example 1 was pretreated at 20 cc/min and at 20°C with 750 cc of ultra low sulfur diesel containing 200 wppm lubricity additive (Tolad 9125). A 5% H_2S in N_2 mixture was bubbled through two litres of crude at 4 ft^3/hr for approximately 0.5 hrs in order to replace any H_2S that may have evolved from the original crude sample. The H_2S/crude mixture was then recycled overnight at 10 cc/min through the column of iron filings to simulate the crude cycle in a pipeline. After crude recirculation, the column was subjected to a series of refined products to simulate the product cycle in a pipeline. All products were pre-purged with an O_2/ N_2 mixture (10%/90%) to simulate typical oxygen levels found in refined products stored in tankage. The ultra low sulfur diesel also contained 200 wppm of Tolad 9125 lubricity additive. The products were pumped through the column of iron filings on a once-through basis at 20 cc/min and at 20°C. The following product cycle was tested: 1) 740 cc of low sulfur gasoline initially containing 1.7 mg/l total sulfur and 0 mg/l of S°, and 2) 740 cc of ULSD initially containing 0.5 mg/l total sulfur and 0 mg/l of S°. Following the product cycle, the column of iron filings was flushed with 300 cc of sulfur-free toluene (air-purged) to remove residual sulfur compounds from the iron filings. The total sulfur content in the products exiting the column was determined by ASTM D5453. The S° content in the products exiting the column was determined by HPLC. The total sulfur pick-up by the products was determined by the subtracting the total sulfur content in the products exiting the column minus the original total sulfur content. The S° pick-up was determined in a similar fashion. The organic sulfur pick-up by the products was determined by subtracting the total sulfur pick-up minus the S° pick-up.

[0022] Table 1 compares the sulfur pick-ups observed with and without pre-treating the column of iron filings with Tolad 9125 lubricity additive. As shown in Table 1, pre-treating the column with lubricity additive significantly reduces the sulfur pick-up observed in all of the products.

Table 1
Effect of Tolad 9125 Lubricity Additive on Sulfur Pick-up

	Example 1	Example 2
Pre-treatment	None	Tolad 9125 Lubricity Additive
Gasoline Sulfur Pick-up		
- Total Sulfur Pick-up, wppm	40	6
- S° Pick-up, wppm	15	1
- Organic Sulfur Pick-up, wppm	25	5
ULSD Sulfur Pick-up		
- Total Sulfur Pick-up, wppm	20	2
- S° Pick-up, wppm	10	0
- Organic Sulfur Pick-up, wppm	10	2

EXAMPLE 3

[0023] A 5% H_2S in N_2 mixture was bubbled through two litres of crude at 4 ft^3/hr for approximately 0.5 hrs in order to replace any H_2S that may have evolved from the original crude sample. The H_2S/crude mixture was then recycled overnight at 10 cc/min and at 20°C through a new 0.75" OD x 18" long column of iron filings (about 40 mesh) to simulate the crude cycle in a pipeline. After crude recirculation the column was subjected to a series of refined products to simulate the product cycle in a pipeline. All products were pre-purged with a O_2/ N_2 mixture (10%/90%) to simulate typical oxygen levels found in refined products stored in tankage. The products were pumped through the column of iron filings on a once-through basis at 20 cc/min. The following product cycle was tested: 1) 740 cc of low sulfur gasoline initially containing 1.7 mg/l total sulfur and 0 mg/l of S°, and 2) 740 cc of ultra low sulfur diesel (ULSD) initially containing 0.5 mg/l total sulfur and 0 mg/l of S°. Following the product cycle the column of iron filings was flushed with 300 cc of sulfur-free toluene (air-purged) to remove residual sulfur compounds from the iron filings. The total sulfur content in the products exiting the column was determined by ASTM D5453. The S° content in the products exiting the column was determined by HPLC. The total sulfur pick-up by the products was determined by the subtracting the total sulfur content in the products exiting the column minus the original total sulfur content. The S° pick-up was determined in a similar fashion. The organic sulfur pick-up by the products was determined by subtracting the total sulfur pick-up minus the S° pick-up.

EXAMPLE 4

[0024] The column of iron filings in Example 3 was pretreated at 20 cc/min at 20°C with 750 cc of ultra low sulfur diesel containing 200 wppm lubricity additive (Lubrizol 539S). A 5% H_2S in N_2 mixture was bubbled through two litres of crude at 4 ft^3/hr for approximately 0.5 hrs in order to replace any H_2S that may have evolved from the original crude sample. The H_2S/crude mixture was then recycled overnight at 10 cc/min through the column of iron filings to simulate the crude cycle in a pipeline. After crude recirculation the column was subjected to a series of refined products to simulate the product cycle in a pipeline. All products were pre-purged with an O_2/ N_2 mixture (10%/90%) to simulate typical oxygen levels found in refined products stored in tankage. The ultra low sulfur diesel also contained 200 wppm of Lubrizol 539S lubricity additive. The products were pumped through the column of iron filings on a once-through basis at 20 cc/min and at 20°C. The following product cycle was tested: 1) 740 cc of low sulfur gasoline initially containing 1.7 mg/l total sulfur and 0 mg/l of S°, and 2) 740 cc of ULSD initially containing 0.5 mg/l total sulfur and 0 mg/l of S°. Following the product cycle, the column of iron filings was flushed with 300 cc of sulfur-free toluene (air-purged) to remove residual sulfur compounds from the iron filings. The total sulfur content in the products exiting the column was determined by ASTM D5453. The S° content in the products exiting the column was determined by HPLC. The total sulfur pick-up by the products was determined by the subtracting the total sulfur content in the products exiting the column minus the original total sulfur content. The S° pick-up was determined in a similar fashion. The organic sulfur pick-up by the products was determined by subtracting the total sulfur pick-up minus the S° pick-up.

[0025] Table 2 compares the sulfur pick-ups observed with and without pre-treating the column of iron filings with Lubrizol 539S lubricity additive. As shown in Table 2, pre-treating the column with lubricity additive significantly reduces the sulfur pick-up observed in all of the products.

Table 2
Effect of Lubrizol 539S Lubricity Additive on Sulfur Pick-up

	Example 1	Example 2
Pre-treatment	None	Lubrizol 539S Lubricity Additive
Gasoline Sulfur Pick-up		
- Total Sulfur Pick-up, wppm	29	10
- S° Pick-up, wppm	13	5
- Organic Sulfur Pick-up, wppm	15	5
ULSD Sulfur Pick-up		
- Total Sulfur Pick-up, wppm	7	2
- S° Pick-up, wppm	3	1
- Organic Sulfur Pick-up, wppm	3	1

[0026] The High Frequency Reciprocating Rig test (HFRR) is commonly used in the industry to determine the effectiveness of a lubricity additive. The HFRR test continuously strokes a steel ball over a flat steel surface in a reciprocating fashion for a period of 75 minutes. A microscope is used to measure the wear scar on the steel ball after completing the HFRR test. Details of the HFRR test can be found in ASTM D6079. Lubricity additives are required for low sulfur diesels since these products do not contain the sulfur species that provide natural lubricity. Typically, low sulfur diesels without any additive yield wear scars in the HFRR test of greater than 550 microns while lubricity additives such as Tolad 9125 and Lubrizol 539S reduce the wear scar to less than 500 microns at a typical dosage rate of 85 wppm.

[0027] The active ingredient in the Tolad 9125 is a fatty acid and an amine derivative, while the active ingredient Lubrizol 539S is a carboxylic acid. Oleic and linoleic acids are typically examples of fatty acids and carboxylic acids while alkanolamines are typically examples of amine derivatives.

CLAIMS:

1. A process for reducing the level of sulfur pick-up in a hydrocarbon stream of interest being transported in a pipeline that is used to transport various sulfur-containing petroleum streams, which process comprises pretreating the inner wall of the pipeline with a hydrocarbon fluid containing an effective amount of a lubricity agent selected from carboxylic acids and carboxylic acid derivatives having from 14 to 40 carbon atoms and containing one or more alcohol groups,

wherein the hydrocarbon fluid is selected from distillate boiling range streams and naphtha boiling range streams containing less than 50 wppm sulfur.

2. The process of claim 1 wherein the hydrocarbon fluid is distillate boiling range stream.

3. The process of claim 1 wherein the amount of lubricity agent used is from 10 wppm to 10,000 wppm in hydrocarbon fluid.

4. The process of claim 3 wherein the pipeline is a virgin pipeline.

5. The process of claim 4 wherein the amount of lubricity agent used is from 1,000 wppm to 10,000 wppm.

6. The process of claim 3 wherein the amount of lubricity agent used is from 10 to 1,000 wppm.

7. The process of claim 1 wherein the lubricity agent is a fatty acid or a fatty acid derivative containing an alcohol or polyol group.

8. The process of claim 7 wherein the fatty acid is selected from oleic acid and linoleic acid.

9. The process of claim 1, wherein the number of carbons is from 16 to 30.

10. A process for reducing the level of sulfur pick-up in a hydrocarbon stream of interest being transported in a pipeline that is used to transport various sulfur-containing petroleum streams, which process comprises pretreating the inner wall of the pipeline with a diesel fuel containing an effective amount of a lubricity agent selected from carboxylic acids and carboxylic acid derivatives having from 14 to 40 carbon atoms and containing one or more alcohol groups,

wherein said effective amount is one that will result in a wear scar diameter of the inner wall of said pipeline, as measured by the HFRR test (ASTM D6079), of less than 500 μm in a low sulfur diesel.

11. The process of claim 10 wherein the diesel fuel contains less than 50 wppm sulfur.

12. The process of claim 10 wherein the amount of lubricity agent used is from 10 wppm to 10,000 wppm in hydrocarbon fluid.

13. The process of claim 12 wherein the pipeline is a virgin pipeline.

14. The process of claim 13 wherein the amount of lubricity agent used is from 1,000 wppm to 10,000 wppm.

15. The process of claim 12 wherein the amount of lubricity agent used is from 10 to 1,000 wppm.

16. The process of claim 10 wherein the lubricity agent is a fatty acid or a fatty acid derivative containing an alcohol or polyol group.

17. The process of claim 16 wherein the fatty acid is selected from oleic acid and linoleic acid.

18. The process of claim 10 wherein the number of carbons is from 16 to 30.

19. A process for reducing the level of sulfur pick-up in a hydrocarbon stream of interest being transported in a virgin pipeline that is used to transport various sulfur-containing petroleum streams, which process comprises pretreating the inner wall of the pipeline with a hydrocarbon fluid containing an effective amount of a carboxylic acid as a lubricity agent the effective amount of lubricity agent comprising from 1,000 to 10,000 wppm of lubricity agent.