

LUBRICATING OIL COMPOSITION FOR TRUNK PISTON DIESEL ENGINE

Technical Field

[0001] The present invention relates to a lubricating oil composition for a
5 medium-speed trunk piston diesel engine, and especially relates to a lubricating
oil composition for a medium-speed 4-stroke trunk piston marine diesel engine.

Background Art

[0002] Trunk piston diesel engines, which are used for marine vessels or
10 production of electric power, use heavy fuels (such as fuel oil C) comprising
asphaltenes in view of economical efficiency. Lubricating oils for trunk piston
diesel engines are required to have detergency to prevent engines from fouling
due to asphaltenes of heavy fuels, and acid-neutralization performance to
neutralize acid components derived from the sulfur content of heavy fuels. A
15 large amount of detergent is incorporated in lubricating oils for trunk piston
diesel engines, so as to satisfy such detergency and acid-neutralization
performance. Lubricating oils for trunk piston diesel engines are required to
have not only solubility of detergent thus incorporated in a large amount, but
also dissolution/dispersing performance for unburned asphaltenes derived
20 from fuels, resin components formed by combustion, and so on. Especially,
dissolution/dispersing of asphaltenes and high temperature detergency are also
important for prevention of formation of black sludge which may lead to
damage to pistons. Lubricating oils for trunk piston diesel engines thus
generally comprise Group I mineral base oils having high aromatic contents.

25 [0003] Patent Literature 1 discloses a medium-speed 4-stroke trunk piston

marine diesel engine oil produced by a process comprising: blending (A) a lubricant additive, in a minor amount, comprising an overbased metal hydrocarbyl-substituted hydroxybenzoate detergent dispersed in a diluent and (B) an additive comprising a polyalkenyl-substituted carboxylic acid anhydride as an active ingredient dispersed in a diluent oil containing 50 mass% or more of a basestock containing greater than or equal to 90% saturates and less than or equal to 0.03% sulfur or a mixture thereof with (C) an oil of lubricating viscosity in a major amount that comprises 50 mass% or more of a basestock containing greater than or equal to 90% saturates and less than or equal to 0.03% sulfur. Patent Literature 1 asserts that such an engine oil can prevent asphaltene precipitation.

Citation List

Patent Literature

[0004] Patent Literature 1: JP 2014-152334 A

Summary of Invention

Technical Problem

[0005] However, supplementary examinations by the present inventor have revealed that the engine oil disclosed by Patent Literature 1 suffers difficulty in improving high-temperature detergency of the oil contaminated with asphaltenes and dissolution/dispersing of asphaltenes at the same time.

[0006] An object of the present invention is to provide a lubricating oil composition for a trunk piston diesel engine which can have improved high-temperature detergency of the composition contaminated with

asphaltenes and improved dissolution/dispersing of asphaltenes at the same time even when a Group II base oil, which is generally inferior to Group I base oils in dissolution/dispersing performance, is employed.

5 Solution to Problem

[0007] The lubricating oil composition for a trunk piston diesel engine of the present invention comprises:

(A) a lubricant base oil comprising one or more selected from the group consisting of: a mineral or synthetic oil having a kinematic viscosity at 100°C of
10 3 to 6 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 5 to 10 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 9 to 13 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 25 to 35 mm²/s, and any combination thereof;

(B) a metallic detergent;

15 (C) a nitrogen-containing ashless dispersant in an amount of 200 to 500 mass ppm in terms of nitrogen on the basis of the total mass of the composition; and

(D) a hydrocarbyl carboxylic anhydride, or a hydrocarbyl carboxylate ester, or any combination thereof.

20 [0008] In one preferred embodiment, the (A) lubricant base oil comprises a base oil having a saturated hydrocarbon content of no less than 90 mass%, a sulfur content of no more than 0.03 mass%, and a viscosity index of no less than 80.

[0009] In one preferred embodiment, the component (C) is an
25 alkenylsuccinimide or a derivative thereof.

[0010] In one preferred embodiment, the component (D) is a hydrocarbyl carboxylic anhydride having a weight average molecular weight of 1,000 to 3,000.

[0011] In another preferred embodiment, the component (D) is a hydrocarbyl carboxylate ester having a weight average molecular weight of 1,000 to 3,000.

[0012] In one preferred embodiment, the lubricating oil composition for a trunk piston diesel engine of the present invention has a base number of 9 to 55 mgKOH/g, the base number being measured by a perchloric acid method.

[0013] In one preferred embodiment, the lubricating oil composition for a trunk piston diesel engine of the present invention has a kinematic viscosity at 100°C of 8.0 to 16.3 mm²/s.

[0014] The lubricating oil composition for a trunk piston diesel engine of the present invention may be preferably used for lubrication of a medium-speed trunk piston diesel engine.

[0015] In the present application, "medium-speed trunk piston diesel engine" means a trunk piston diesel engine which has a rated number of rotations (number of rotations at maximum continuous power, which is also referred to as maximum continuous number of rotations or continuous rating number of rotations) of 200 to 1250 rpm. The number of rotations is typically 300 to 1000 rpm.

Advantageous Effects of Invention

[0016] The lubricating oil composition for a trunk piston diesel engine of the present invention can have improved high-temperature detergency of the

composition contaminated with asphaltenes and improved asphaltene dissolution/dispersing performance at the same time, even when a Group II base oil, which is generally inferior to Group I base oils in dissolution/dispersing performance, is employed.

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Brief Description of Drawings

[0017] Fig 1 shows states of spots which correspond to ratings of 0 to 5 respectively in spot testing.

10 Description of Embodiments

[0018] The present invention will be described in detail hereinafter. Expression "A to B" concerning numeral values A and B means "no less than A and no more than B" unless otherwise specified. In such expression, if a unit is added only to the numeral value B, the unit is applied to the numeral value A as well. A word "or" means a logical sum unless otherwise specified.

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[0019] <(A) Lubricant base oil>

A lubricant base oil in the lubricating oil composition for a trunk piston diesel engine of the present invention is a lubricant base oil comprising one or more selected from the group consisting of: a mineral or synthetic oil having a kinematic viscosity at 100°C of 3 to 6 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 5 to 10 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 9 to 13 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 25 to 35 mm²/s, and any combination thereof;

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[0020] Mineral base oils that are ordinarily used for a lubricating oil may be used as the mineral oils without particular limitations. Specific examples

25

thereof include: oils obtained by refining lubricant oil fractions that are obtained by vacuum distillation of atmospheric residues obtained by atmospheric distillation of crude oils, through at least one of such processes as solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, and
5 hydrorefining; wax isomerized mineral oils; and lubricant base oils produced by a process of isomerizing GTL WAX (gas to liquid wax) that is produced by a Fischer-Tropsch process, and the like.

[0021] The total aromatic content of (a) mineral base oil(s) other than a base oil (A-1) described later is not specifically limited, and is preferably no more
10 than 40 mass%, and more preferably no more than 30 mass%. The total aromatic content may be 0 mass%, and in view of solubility of additives, is preferably no less than 1 mass%, is further preferably no less than 5 mass%, is further preferably no less than 10 mass%, and is especially preferably no less than 20 mass%. (A) base oil(s) whose total aromatic content is over 40 mass%
15 is inferior in oxidation stability, which is not preferable. The total aromatic content means an aromatic fraction content measured conforming to ASTM D2549. An aromatic fraction content normally includes alkylbenzene; alkylnaphthalenes; anthracene, phenanthrene, and alkylated derivatives thereof; compounds having 4 or more fused benzene rings; and heteroaromatics
20 such as pyridines, quinolines, phenols, and naphthols.

[0022] The sulfur content of (a) mineral base oil(s) other than the base oil (A-1) described later is not specifically limited, and is preferably no more than 1 mass%, and is further preferably no more than 0.5 mass%; and is preferably no less than 0.1 mass%, and is more preferably no less than 0.2 mass%.
25 Employment of a mineral base oil having some sulfur content makes it possible

to improve solubility of additives.

[0023] Synthetic base oils that are ordinarily used for a lubricating oil may be used as the synthetic oils without particular limitations. Specific examples thereof include: polybutene and hydrogenated products thereof; poly- α -olefins
5 and hydrogenated products thereof, examples thereof including oligomers of 1-octene, 1-decene, dodecene, etc., or oligomers of mixtures thereof; diesters such as ditridecyl glutarate, bis(2-ethylhexyl) adipate, diisodecyl adipate, ditridecyl adipate, and bis(2-ethylhexyl) sebacate; polyol esters such as trimethylolpropane caprilate, trimethylolpropane pelargonate, pentaerythritol
10 2-ethylhexanoate, and pentaerythritol pelargonate; copolymers of dicarboxylic acids such as dibutyl maleate and C_{2-30} α -olefins; aromatic synthetic oils such as alkylnaphthalenes, alkylbenzenes, and aromatic esters; and mixtures thereof.

[0024] Examples of the mineral or synthetic oil having a kinematic viscosity at 100°C of 3 to 6 mm²/s include mineral and synthetic base oils of SAE10 etc.
15 Examples of the mineral or synthetic oil having a kinematic viscosity at 100°C of 5 to 10 mm²/s include mineral and synthetic base oils of SAE20 etc. Examples of the mineral or synthetic oil having a kinematic viscosity at 100°C of 9 to 13 mm²/s include mineral and synthetic base oils of SAE30 etc. Examples of the mineral or synthetic oil having a kinematic viscosity at 100°C of 25 to 35 mm²/s
20 include bright stock etc.

[0025] The viscosity index of the lubricant base oil is not specifically limited. In view of good viscosity characteristics in a range from low to high temperature, the viscosity index is preferably no less than 80, more preferably no less than 85, and further preferably no less than 90. The upper limit of the
25 viscosity index is not specifically restricted, and in view of solubility of

additives and storage stability, is preferably no more than 170, and is more preferably no more than 160.

[0026] The evaporation loss of the lubricant base oil is not specifically restricted, and in view of oil consumption, is preferably no more than 20 mass%,
5 is further preferably no more than 16 mass%, and is especially preferably no more than 10 mass%, in terms of NOACK evaporation loss (evaporation loss of a lubricating oil measured conforming to ASTM D 5800).

[0027] In the present invention, the lubricant base oil preferably includes the following base oil (A-1):

10 (A-1) a base oil having a saturated hydrocarbon content of no less than 90 mass%, a sulfur content of no more than 0.03 mass%, and a viscosity index of no less than 80.

The saturated hydrocarbon content in the present application is a saturated content measured according to the method specified in ASTM D
15 2007-93.

The base oil (A-1) may be either a mineral or synthetic base oil, and is preferably a mineral base oil. A Group II base oil in API base stock categories may be preferably used as the base oil (A-1).

[0028] The saturated hydrocarbon content of the base oil (A-1) is no less
20 than 90 mass%, and preferably no less than 95 mass%; and preferably no more than 99.5 mass%.

The aromatic content of the base oil (A-1) is no more than 10 mass%, preferably less than 5 mass%, and more preferably less than 3 mass%, and may be 0 mass%.

25 The viscosity index of the base oil (A-1) is no less than 80, preferably no

less than 85, more preferably no less than 90, and normally less than 120.

[0029] The content of the base oil (A-1) is preferably 70 to 100 mass%, and more preferably 80 to 90 mass%, on the basis of the total mass of the (A) lubricant base oil. The content of the base oil (A-1) of this lower limit or over
5 leads to good oxidation stability. The (A) lubricant base oil comprising less than or equal to the upper limit of the base oil (A-1) and a mineral base oil having a higher aromatic content (e.g., a Group I base oil of API base stock categories) offers sufficient solubility. The aromatic content of (an) other mineral base oil(s) used in combination with the base oil (A-1) is preferably no
10 less than 1 mass%, and more preferably no less than 5 mass%, as described above.

[0030] The content of the (A) lubricant base oil is normally 65 to 95 mass%, and preferably 70 to 90 mass%, on the basis of the total mass of the lubricating oil composition for a trunk piston diesel engine.

15 [0031] <(B) Metallic detergent>

One or combination of at least two selected from a calcium salicylate detergent, a calcium phenate detergent, and a calcium sulfonate detergent may be preferably used as the metallic detergent in the lubricating oil composition of the present invention. In the lubricating oil composition for a trunk piston
20 diesel engine of the present invention, the metallic detergent is preferably a calcium salicylate detergent and/or a calcium phenate detergent, and more preferably includes at least a calcium salicylate detergent.

[0032] The content of the metallic detergent in the lubricating oil composition of the present invention is, as containing a diluent, usually 7 to 30
25 mass%, preferably 8 to 25 mass%, and more preferably 10 to 25 mass%, on the

basis of the total mass of the composition. More than or equal to the lower limit of the metallic detergent offers improved performance to neutralize sulfuric acid originated from heavy fuels, and improved engine detergency at the same time. Less than or equal to the upper limit of the metallic detergent
5 offers better solubility in the base oil.

[0033] A calcium salicylate-based detergent may be produced according to a known method without any particular limitations. For example, a calcium salicylate-based detergent may be produced by: making a calcium base such as calcium oxide and calcium hydroxide react with an alkylsalicylic acid produced
10 by alkylating 1 mol of a phenol with 1 mol or more of a C₁₀₋₄₀ olefin such as polymers and copolymers of ethylene, propylene, butene, etc., preferably a linear α -olefin such as ethylene polymers, and then carboxylating the resultant product with carbonic acid gas or the like, by alkylating 1 mol of a salicylic acid with 1 mol or more of the olefin, preferably the linear α -olefin, or the like; or,
15 making the alkylsalicylic acid an alkali metal salt such as a sodium salt and a potassium salt, and then substituting calcium ions for alkali metal ions; or the like. These reactions are usually conducted in an aliphatic hydrocarbon solvent such as hexane, an aromatic hydrocarbon solvent such as xylene, and solvent such as a light lubricant base oil.

20 [0034] Calcium salicylate-based detergents encompass basic salts obtainable by further heating calcium salicylates that are obtained as described above (neutral salts) together with excess calcium salts or calcium bases (calcium oxide or calcium hydroxide) in the presence of water, and overbased salts obtainable by making the neutral salts react with bases such as calcium
25 hydroxide in the presence of carbonic acid gas, or boric acid or a borate salt.

[0035] Preferred examples of a calcium phenate detergent include: calcium salts of alkylphenol sulfides obtainable by reacting sulfur and alkylphenols having at least one C₄₋₃₀, preferably C₁₀₋₁₈ linear or branched alkyl group; and calcium salts of Mannich reaction products of alkylphenols obtainable by
5 reacting alkylphenols and formaldehyde. Calcium phenate detergents encompass basic salts obtainable by further heating neutral salts of calcium phenates together with excess calcium salts or calcium bases (calcium oxide or calcium hydroxide) in the presence of water, and overbased salts obtainable by making the neutral salts react with bases such as calcium hydroxide in the
10 presence of carbonic acid gas, or boric acid or a borate salt.

[0036] Examples of a calcium sulfonate detergent include: calcium salts of alkylaromatic sulfonic acids obtainable by sulfonating alkylaromatic compounds, and basic salts and overbased salts thereof. The weight average molecular weight of the alkylaromatic compounds is preferably 400 to 1500, and
15 more preferably 700 to 1300.

Examples of alkylaromatic sulfonic acids include what is called petroleum sulfonic acids and synthetic sulfonic acids. Examples of petroleum sulfonic acids here include sulfonated products of alkylaromatics of lubricant oil fractions derived from mineral oils, and what is called mahogany acid,
20 which is side product of white oils. Examples of synthetic sulfonic acids include sulfonated products of alkylbenzene having a linear or branched alkyl group, obtainable by recovering side product in a manufacturing plant of alkylbenzene, which is raw material of detergents, or by alkylating benzene with a polyolefin. Another example of synthetic sulfonic acids is a sulfonated
25 product of alkylnaphthalenes such as dinonylnaphthalene. Sulfonating agents

used when sulfonating these alkylaromatics are not limited. For example, a fuming sulfuric acid and a sulfuric anhydride may be used.

Calcium sulfonate detergents encompass basic salts obtainable by further heating neutral salts of calcium sulfonates together with excess calcium salts or calcium bases (calcium oxide or calcium hydroxide) in the presence of water, and overbased salts obtainable by making the neutral salts react with bases such as calcium hydroxide in the presence of carbonic acid gas, or boric acid or a borate.

[0037] The base number of the metallic detergent in the lubricating oil composition of the present invention is not specifically limited as long as making it possible that the base number of the lubricant base oil composition is within a desired range described later, and is normally 0 to 500 mgKOH/g, and is preferably 20 to 450 mgKOH/g.

[0038] <(C) Nitrogen-containing ashless dispersant>

A known ashless dispersant that is used for a lubricating oil may be used as the nitrogen-containing ashless dispersant in the lubricating oil composition of the present invention without any particular limitations. Examples thereof include nitrogen-containing compounds having at least one C₄₀₋₄₀₀ linear or branched alkyl or alkenyl group in each molecule thereof, and derivatives thereof.

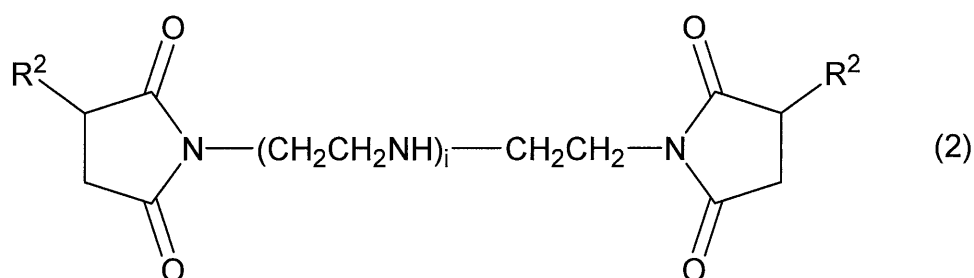
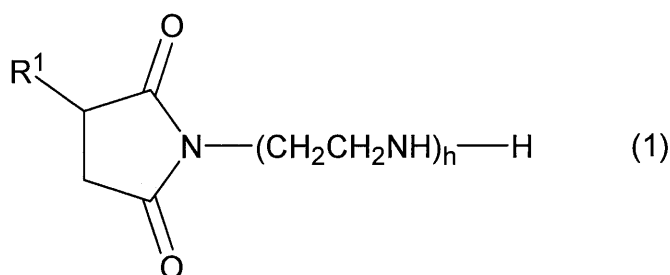
[0039] Examples of the nitrogen-containing compounds include succinimides, benzylamines, polyamines, Mannich bases, and examples of derivatives thereof include derivatives obtainable by reacting the nitrogen-containing compounds with boron compounds such as boric acid and borate salts, phosphorus compounds such as (thio)phosphoric acid and

(thio)phosphate salts, organic acids, hydroxy(poly)oxyalkylene carbonate, etc. In the present invention, any one or at least any two selected among them may be incorporated.

[0040] As the nitrogen-containing ashless dispersant, an alkenylsuccinimide or a derivative thereof is preferable in view of improving high-temperature detergency, and a boron-containing alkenylsuccinimide ashless dispersant is especially preferable in view of improving anti-seizure performance.

[0041] Examples of alkenylsuccinimides include compounds represented by the following formulae (1) and (2):

10 [0042]



[0043] In the formula (1), R¹ represents a C₄₀₋₄₀₀ alkenyl group, and h represents an integer of 1 to 5, preferably 2 to 4. The carbon number of R¹ is preferably no less than 60, and preferably no more than 350.

15 [0044] In the formula (2), R² each independently represents a C₄₀₋₄₀₀ alkenyl group, and may be combination of different groups. R² are especially preferably polybutenyl groups. i represents an integer of 0 to 4, preferably 1 to

3. The carbon numbers of R² are preferably no less than 60, and preferably no more than 350.

[0045] The carbon numbers of R¹ and R² in the formulae (1) and (2) of the lower limit or more makes it possible to obtain good solubility in the lubricant
5 base oil. In contrast, the carbon numbers of R¹ and R² of the upper limit or below makes it possible to improve low-temperature fluidity of the lubricating oil composition of the present invention.

[0046] The alkenyl groups (R¹ and R²) in the formulae (1) and (2) may be either linear or branched. Preferred examples thereof include: branched
10 alkenyl groups derived from oligomers of olefins such as propylene, 1-butene, and isobutene, and cooligomers of ethylene and propylene. Among them, most preferable is a branched alkenyl group derived from an isobutene oligomer conventionally referred to as polyisobutylene, or a polybutenyl group.

The weight average molecular weights of the alkenyl groups (R¹ and R²)
15 in the formulae (1) and (2) are preferably 800 to 3500.

[0047] Alkenylsuccinimides encompass a so-called mono-type succinimide represented by the formula (1), where a succinic anhydride terminates only one end of a polyamine chain, and a so-called bis-type succinimide represented by the formula (2), where succinic anhydrides terminate both ends of a polyamine
20 chain. The lubricating oil composition of the present invention may contain either a monotype or bis-type succinimide, and may contain both of them as a mixture.

[0048] Methods for producing the alkenylsuccinimides are not specifically limited. For example, an alkenylsuccinimide may be obtained by: reacting an
25 alkenyl succinic acid obtained by reacting a compound having a C₄₀₋₄₀₀ alkenyl

group with maleic anhydride at 100 to 200°C, with a polyamine. Here, examples of a polyamine include diethylenetriamine, triethylenetetramine, tetraethylenepentamine, and pentaethylenehexamine.

[0049] Examples of boronated derivatives of alkenylsuccinimides include
5 so-called boron-modified products where a part or all of the residual amino and/or imino groups is/are neutralized or amidated by making boric acid react with the above described alkenylsuccinimides.

The molecular weight of the component (C) is not specifically limited, and the weight average modular weight thereof is preferably 1000 to 8000.

10 [0050] The content of the nitrogen-containing ashless dispersant is, in view of improving dissolution/dispersing of asphaltenes and improving water-separability for an aqueous washing treatment in oil purifiers of diesel engines, no more than 500 mass ppm, and preferably no more than 450 mass ppm, on the basis of the total mass of the composition in terms of nitrogen. In
15 view of improving high-temperature detergency of the composition contaminated with asphaltenes, the content thereof is preferably no less than 200 mass ppm, and more preferably no less than 300 mass ppm, on the basis of the total mass of the composition in terms of nitrogen.

[0051] When the nitrogen-containing ashless dispersant contains boron, the
20 content thereof in terms of boron is normally 100 to 900 mass ppm, and preferably no less than 200 mass ppm; and preferably no more than 500 mass ppm, on the basis of the total mass of the composition.

[0052] <(D) Hydrocarbyl carboxylic anhydride and/or hydrocarbyl carboxylate ester>

25 The lubricating oil composition of the present invention comprises a

hydrocarbyl carboxylic anhydride, or a hydrocarbyl carboxylate ester, or any combination thereof. The weight average molecular weight of the component (D) is preferably 1,000 to 3,000, and more preferably 1,500 to 2,500.

[0053] A hydrocarbyl group in the hydrocarbyl carboxylic anhydride is preferably an alkyl or alkenyl group, and more preferably an alkenyl group. The carbon number of a hydrocarbyl group in the hydrocarbyl carboxylic anhydride is preferably no less than 20, and more preferably 50 to 200.

A hydrocarbyl carboxylic acid composing the hydrocarbyl carboxylic anhydride may be a monobasic acid (monocarboxylic acid), a dibasic acid (dicarboxylic acid), or a tribasic acid (tricarboxylic acid), or any combination thereof. Preferred examples of the hydrocarbyl carboxylic acid composing the hydrocarbyl carboxylic anhydride include polybutenylsuccinic acid.

In the present invention, any one of acid anhydrides formed by intramolecular dehydration of the hydrocarbyl dicarboxylic acid may be preferably employed as the hydrocarbyl carboxylic anhydride of the component (D). Among them, an alkenylsuccinic anhydride may be especially preferably employed.

[0054] A hydrocarbyl group in the hydrocarbyl carboxylate ester is preferably an alkyl or alkenyl group, and more preferably an alkenyl group. The carbon number of a hydrocarbyl group in the hydrocarbyl carboxylate ester is preferably no less than 100, and more preferably no less than 200.

A hydrocarbyl carboxylic acid composing the hydrocarbyl carboxylate ester may be a monobasic acid (monocarboxylic acid), a dibasic acid (dicarboxylic acid), or a tribasic acid (tricarboxylic acid), or any combination thereof. When the hydrocarbyl carboxylic acid has two or more carboxy

groups, its ester may be a complete ester, or an incomplete ester. Preferred examples of the hydrocarbyl carboxylic acid composing the hydrocarbyl carboxylate ester include polybutenylsuccinic acid.

An alcohol composing the hydrocarbyl carboxylate ester may be a monovalent alcohol (monool), a divalent alcohol (diol), or a trivalent alcohol (triol), or any combination thereof. The alcohol composing the hydrocarbyl carboxylate ester is preferably an aliphatic alcohol. Preferred examples of the alcohol composing the hydrocarbyl carboxylate ester include ethylene glycol, and propylene glycol.

In the present invention, any one of hydrocarbyl dicarboxylate esters may be preferably employed as the hydrocarbyl carboxylate ester of the component (D). Among them, an alkenylsuccinate ester may be especially preferably employed.

[0055] The content of the component (D) in the lubricating oil composition of the present invention is normally 0.5 to 5.0 mass%, and preferably no less than 1.0 mass%; and preferably no more than 3.0 mass%, on the basis of the total mass of the composition.

[0056] <Other additives>

The lubricating oil composition of the present invention may further comprise at least one additive selected from the group consisting of an anti-wear agent or an extreme-pressure agent, a friction modifier, an antioxidant, a viscosity index improver, a pour point depressant, a metal deactivator, a corrosion inhibitor, an anti-rust agent other than the component (D), a demulsifier, and a defoaming agent, in addition to the lubricant base oil, the metallic detergent, the ashless dispersant, and the hydrocarbyl carboxylic

anhydride/carboxylate ester.

[0057] A known anti-wear agent or extreme-pressure agent may be used without specific limitations. Examples thereof include sulfur-based, phosphorus-based, and sulfur-phosphorus-based extreme pressure agents.

5 Specific examples thereof include zinc dithiophosphates, phosphorous esters, thiophosphorous esters, dithiophosphorous esters, trithiophosphorous esters, phosphate esters, thiophosphate esters, dithiophosphate esters, trithiophosphate esters, amine salts thereof, metal salts thereof, derivatives thereof, dithiocarbamates, disulfides, polysulfides, sulfurized olefins, and
10 sulfurized fats. When the lubricating oil composition of the present invention contains such an anti-wear agent or extreme-pressure agent, the content thereof is normally 0.01 to 5 mass% on the basis of the total mass of the composition.

[0058] A known ashless friction modifier or a molybdenum friction modifier may be used as a friction modifier without specific limitations. Examples of an
15 ashless friction modifier include ashless friction modifiers such as fatty amine compounds, fatty imide compounds, fatty acid esters, fatty acid amides, fatty acids, aliphatic alcohols, aliphatic esters, aliphatic ureas, and aliphatic hydrazides, each of which has at least one C₆₋₃₀ hydrocarbyl group in the molecule. Examples of a molybdenum friction modifier include organic
20 molybdenum compounds such as molybdenum dithiocarbamate, molybdenum dithiophosphate, and molybdenum-amine complexes. When the lubricating oil composition of the present invention contains a friction modifier, the total content thereof is normally 0.2 to 5 mass% on the basis of the total mass of the composition.

25 [0059] A known antioxidant may be used without specific limitations.

Examples thereof include phenol antioxidants such as 2,6-ditert-butyl-4-methylphenol (DBPC), and 4,4'-methylenebis(2,6-ditert-butylphenol); amine antioxidants such as alkyldiphenylamines, and (alkyl)phenyl- α -naphthylamines; and metallic
5 antioxidants. When the lubricating oil composition of the present invention contains an antioxidant, the content thereof is normally 0.1 to 5 mass% on the basis of the total mass of the composition.

[0060] A known viscosity index improver may be used without specific limitations. Examples thereof include non-dispersant or dispersant ester
10 group-containing viscosity index improvers, non-dispersant or dispersant poly(meth)acrylate viscosity index improvers, hydrogenated styrene-diene copolymers, non-dispersant or dispersant ethylene- α -olefin copolymers or hydrogenated products thereof, polyisobutylene or hydrogenated products thereof, styrene-maleic anhydride/ester copolymers, polyalkylstyrene, and
15 (meth)acrylate-olefin copolymers. The weight average molecular weight of a viscosity index improver is normally 10,000 to 400,000. When the lubricating oil composition of the present invention contains a viscosity index improver, the content thereof is normally 1.0 to 15.0 mass% on the basis of the total mass of the composition.

[0061] A known pour point depressant such as polymethacrylate polymers
20 may be used according to the properties and conditions of the employed lubricant base oil without specific limitations. When the lubricating oil composition of the present invention contains a pour point depressant, the content thereof is usually 0.01 to 1 mass% on the basis of the total mass of the
25 composition.

[0062] A known corrosion inhibitor such as benzotriazole, tolyltriazole, thiadiazole, and imidazole compounds may be used without specific limitations. When the lubricating oil composition of the present invention contains such a corrosion inhibitor, the content thereof is usually 0.005 to 5 mass% on the basis
5 of the total mass of the composition.

[0063] A known anti-rust agent such as petroleum sulfonates, alkylbenzene sulfonates, dinonylnaphthalene sulfonates, and polyalcohol esters may be used as an anti-rust agent other than the component (D) without specific limitation. When the lubricating oil composition of the present invention contains such an
10 anti-rust agent, the content thereof is usually 0.005 to 5 mass% on the basis of the total mass of the composition.

[0064] A known demulsifier such as polyoxyalkylene glycol-based nonionic surfactants, examples thereof including polyoxyethylene alkyl ethers, polyoxyethylene alkylphenyl ethers, and polyoxyethylene alkylnaphthyl ethers
15 may be used without specific limitation. When the lubricating oil composition of the present invention contains such a demulsifier, the content thereof is usually 0.005 to 5 mass% on the basis of the total mass of the composition.

[0065] A known metal deactivator may be used without specific limitation. Examples thereof include imidazoline, pyrimidine derivatives, alkylthiadiazoles, mercaptobenzothiazoles, benzotriazole or derivatives thereof, 1,3,4-thiadiazole
20 polysulfide, 1,3,4-thiadiazolyl-2,5-bisdialkyldithiocarbamates, 2-(alkyldithio)benzimidazoles, and β -(o-carboxybenzylthio)propionitrile. When the lubricating oil composition of the present invention contains such a metal deactivator, the content thereof is normally 0.005 to 1 mass% on the basis
25 of the total mass of the composition.

[0066] A known defoaming agent such as silicones, fluorosilicones, and fluoroalkyl ethers may be used without specific limitation. When the lubricating oil composition of the present invention contains such a defoaming agent, the content thereof is usually 0.0005 to 1 mass% on the basis of the total mass of the composition.

[0067] <Lubricating oil composition>

The kinematic viscosity at 100°C of the lubricating oil composition of the present invention is normally 8.0 to 16.3 mm²/s, preferably 9.0 to 15.0 mm²/s, more preferably 9.0 to 12.5 mm²/s, and especially preferably 10.0 to 12.5 mm²/s.

The kinematic viscosity of the composition under 8.0 mm²/s may lead to difficulty in having sufficient oil film thickness and hydraulic pressure necessary for reliability of middle-speed diesel engines. The kinematic viscosity of the composition over 16.3 mm²/s may lead to difficulty in reducing fuel consumption. The kinematic viscosity at 100°C here means a kinematic viscosity at 100°C specified in ASTM D 445.

[0068] The base number of the lubricating oil composition of the present invention is, in view of having good high-temperature detergency and acid neutralization performance even when a high-sulfur fuel containing asphaltenes is used, preferably no less than 9 mgKOH/g, and more preferably no less than 10 mgKOH/g. In view of avoiding bore polishing and scuffing of liners due to deposition of an excess ash content onto piston top lands, the base number thereof is preferably no more than 55 mgKOH/g, and more preferably no more than 50 mgKOH/g.

The base number in the present application represents a base number measured by the perchloric acid method conforming to ASTM D 2896.

[0069] The sulfated ash content of the lubricating oil composition of the present invention is not specifically restricted, and is preferably no less than 0.9 mass%, and is more preferably no less than 1.2 mass%; and is preferably no more than 7.0 mass%, and is more preferably no more than 6.5 mass%. In the present application, the sulfated ash content represents a value measured according to the method specified in 5. "Determination of sulfated ash" in JIS K2272, and mainly derives from metal-containing additives.

Examples

[0070] Hereinafter the present invention will be more specifically described based on Examples and Comparative Examples. The present invention is not limited to these examples.

[0071] <Examples 1 to 7 and Comparative Examples 1 to 7>

As shown in Table 1, the lubricating oil compositions of the present invention (Examples 1 to 7) and lubricating oil compositions for comparison (Comparative Examples 1 to 7) were prepared. In the Table, "inmass%" represents mass% on the basis of the mass of the total base oils, "mass%" represents mass% on the basis of the total mass of the composition, and "mass ppm" represents mass ppm on the basis of the total mass of the composition.

	Examples							Comparative examples						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Base oil														
Base oil 1 (*1)	inmass%	40	40	40	40	40	40	40	40	40	40	40	40	40
Base oil 2 (*2)	inmass%	50	50	50	50	50	50	50	50	50	50	50	50	50
Base oil 3 (*3)	inmass%	10	10	10	10	10	10	10	10	10	10	10	10	10
Additives														
Ca phenate (*4)	mass%	2.4	2.4											
Ca salicylate a (*5)	mass%	3.5	3.5											
Ca salicylate b (*6)	mass%		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Ca salicylate c (*7)	mass%	3.9	3.9											
Ca salicylate d (*8)	mass%	2.8	2.8	7	7	7	7	7	7	7	7	7	7	7
Polybutenylsuccinimide (*9)	mass%	2	2	2	2	1.5	1	4	3	2	1		2	3
Polybutenylsuccinic anhydride a (*10)	mass%	1		1									1	
Polybutenylsuccinic anhydride b (*11)	mass%		1		1									1
Polybutenylsuccinate ester (*12)	mass%						1.72							
Zinc dithiophosphate	mass ppm	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Nitrogen content derived from dispersant	mass ppm	440	440	440	440	330	220	880	660	440	220	0	660	660
Base number (perchloric acid method)	mgKOH/g	30.0	30.0	30.1	30.1	30.0	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1
Kinematic viscosity (40°C)	mm ² /s	93.0	86.6	94.0	94.0	93.0	93.5	102.0	94.0	89.0	87.0	91.0	96.0	96.5
Kinematic viscosity (100°C)	mm ² /s	11.8	11.3	11.9	11.8	11.4	11.7	12.5	11.8	11.4	11.1	11.5	12.0	11.9
Viscosity index		114	113	114	112	112	112	112	113	113	112	112	113	111
Hot tube test														
Fresh oil + fuel oil C (10%), 300°C, 16 h	Rating	3.5	3.5	3.0	2.5	2.5	2.0	3.5	4.5	3.5	1.5	0.5	4.0	4.5
Spot test														
Fresh oil + fuel oil C (10%)	Rating	3	4	3	4	4	3	2	0	0	1	2	4	0
(*1) Base oil 1: Group II base oil, kinematic viscosity (40°C) 31.0 mm ² /s, kinematic viscosity (100°C) 5.6 mm ² /s, viscosity index 119, saturated content 98.8%, aromatic content 0.8%, resin content 0.4%, N content less than 3 ppm, S content 0.01%														
(*2) Base oil 2: Group II base oil, kinematic viscosity (40°C) 93.9 mm ² /s, kinematic viscosity (100°C) 10.7 mm ² /s, viscosity index 97, saturated content 98.9%, aromatic content 0.9%, resin content 0.2%, N content less than 3 ppm, S content 0.01%														
(*3) Base oil 3: Group I base oil, kinematic viscosity (40°C) 476.1 mm ² /s, kinematic viscosity (100°C) 31.4 mm ² /s, viscosity index 96, saturated content 60.8%, aromatic content 36.7%, resin content 2.5%, N content 54 ppm, S content 0.44%														
(*4) Ca phenate: base number 255 mgKOH/g														
(*5) Ca salicylate a: Ca alkylsalicylate having an alkyl group derived from C ₁₄₋₁₈ and C ₂₀₋₃₀ olefins, base number 170 mgKOH/g														
(*6) Ca salicylate b: Ca alkylsalicylate having an alkyl group derived from a C ₁₄₋₁₈ olefin, base number 170 mgKOH/g														
(*7) Ca salicylate c: Ca alkylsalicylate having an alkyl group derived from a C ₂₀₋₃₀ olefin, base number 230 mgKOH/g														
(*8) Ca salicylate d: Ca alkylsalicylate having an alkyl group derived from a C ₂₀₋₃₀ olefin, base number 320 mgKOH/g														
(*9) Boronated alkenylsuccinimide: N content 2.2%, B content 2.2%														
(*10) Polybutenylsuccinic anhydride a: Mw 2300														
(*11) Polybutenylsuccinic anhydride b: Mw 1000														
(*12) Polybutenylsuccinate ester: LZ-936 manufactured by The Lubrizol Corporation														

[0073] (Evaluation (1): hot tube test)

So as to evaluate high-temperature detergency of the compositions contaminated with asphaltenes, a mixture consisting of 90 mass% of a sample oil and 10 mass% of fuel oil C was prepared for each of the lubricating oil compositions of Examples 1 to 7 and Comparative Examples 1 to 7, and the mixture was subjected to hot tube test. The testing temperature was 300°C and the testing time was 16 hours. The results are shown in Table 1. Higher ratings mean better high-temperature detergency of the compositions contaminated with asphaltenes.

10 [0074] (Evaluation (2): spot test)

So as to evaluate asphaltene dissolution/dispersing performance of the compositions, a mixture consisting of 90 mass% of a sample oil, and 10 mass% of fuel oil C was prepared for each of the lubricating oils of Examples 1 to 7 and Comparative Examples 1 to 7, and one drop of the mixture was put down onto filter paper. After 12 hours have passed, a state of a ring-like spot appearing on the filter paper was evaluated using 6 ratings of 0 to 5. States of spots which correspond to the ratings of 0 to 5 respectively are as shown in Fig. 1. The results are shown in Table 1. Higher ratings mean better asphaltene dissolution/dispersing performance.

20 [0075] (Evaluation results)

As can be seen from Table 1, all the lubricating oil compositions of Examples 1 to 7 showed improved high-temperature detergency of the compositions contaminated with asphaltenes and improved asphaltene dissolution/dispersing performance at the same time despite containing 90 mass% of the Group II base oils on the basis of the mass of the total base oils.

The results of the lubricating oil compositions of Comparative Examples 1 to 4, which did not contain the component (D) (hydrocarbyl carboxylic anhydride/carboxylate ester), were inferior to those of Examples 1 to 7 in either or both high-temperature detergency of the compositions contaminated with asphaltenes and/or asphaltene dissolution/dispersing performance.

The result of the lubricating oil composition of Comparative Example 5, whose content of the (C) ashless dispersant was below the range of the present invention, was inferior to those of Examples 1 to 7 in high-temperature detergency of the compositions contaminated with asphaltenes.

The results of the lubricating oil composition of Comparative Examples 6 to 7, whose contents of the (C) ashless dispersants were beyond the range of the present invention, were inferior to those of Examples 1 to 7 in dissolution/dispersing performance of asphaltenes.

[0076] These results showed that the lubricating oil composition for a trunk piston diesel engine of the present invention can have improved high-temperature detergency of the composition contaminated with asphaltenes and improved asphaltene dissolution/dispersing performance at the same time even when a Group II base oil, which is generally inferior to Group I base oils in dissolution/dispersing performance, is employed.

I/We claim:

1. A lubricating oil composition for a trunk piston diesel engine comprising:

5 (A) a lubricant base oil comprising one or more selected from the group consisting of: a mineral or synthetic oil having a kinematic viscosity at 100°C of 3 to 6 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 5 to 10 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 9 to 13 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of 25 to 35 mm²/s, and any combination thereof;

(B) a metallic detergent;

(C) a nitrogen-containing ashless dispersant in an amount of 200 to 500 mass ppm in terms of nitrogen on the basis of the total mass of the composition; and

15 (D) a hydrocarbyl carboxylic anhydride, or a hydrocarbyl carboxylate ester, or any combination thereof.

2. The lubricating oil composition according to claim 1,

wherein the (A) lubricant base oil comprises a base oil having a 20 saturated hydrocarbon content of no less than 90 mass%, a sulfur content of no more than 0.03 mass%, and a viscosity index of no less than 80.

3. The lubricating oil composition according to claim 1 or 2,

wherein the component (C) is an alkenylsuccinimide or a derivative 25 thereof.

4. The lubricating oil composition according to any one of claims 1 to 3,
wherein the component (D) is a hydrocarbyl carboxylic anhydride
having a weight average molecular weight of 1,000 to 3,000.

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5. The lubricating oil composition according to any one of claims 1 to 3,
wherein the component (D) is a hydrocarbyl carboxylate ester having a
weight average molecular weight of 1,000 to 3,000.

10 6. The lubricating oil composition according to any one of claims 1 to 5,
wherein the lubricating oil composition has a base number of 9 to 55
mgKOH/g, the base number being measured by a perchloric acid method.

7. The lubricating oil composition according to any one of claims 1 to 6,
15 wherein the lubricating oil composition has a kinematic viscosity at
100°C of 8.0 to 16.3 mm²/s.

8. The lubricating oil composition according to any one of claims 1 to 7,
which is a lubricating oil composition for a medium-speed trunk piston diesel
20 engine.