

DESCRIPTION

LUBRICATING OIL COMPOSITION FOR TRUNK PISTON DIESEL ENGINE

5 Technical Field

[0001] The present invention relates to lubricating oil compositions for medium speed trunk piston diesel engines, and specifically relates to lubricating oil compositions for medium speed four-stroke trunk piston marine diesel engines.

10 Background Art

[0002] For diesel engines used for ships and power generation, heavy fuels (e.g. C heavy oil) including asphaltene components are used in view of economic efficiency. For a lubricating oil composition for such diesel engines, demanded are cleaning action to prevent fouling of the engines by the asphaltene components in heavy fuels, acid neutralizing property to neutralize the acid components derived from sulfur in heavy fuels, and water separation property for washing treatments with water by an oil purifying device. In addition, medium speed four-stroke trunk piston marine diesel engines are operated at a lower speed of approximately 200 rpm to 1200 rpm, generally at a constant speed, and operated under the conditions of higher temperature and higher load. Thus, a lubricating oil having a high viscosity is commonly used as a lubricating oil for medium speed four-stroke trunk piston marine diesel engines, in order to secure a proper oil film thickness at lubricating faces of the cylinder liner, bearing, cam, etc..

[0003] In response to the recent trend of energy saving, reduction of fuel consumption is also demanded in marine diesel engines. For example, Patent Literature 1 points out that the wear of the top ring of the piston in a trunk piston diesel engine increases the fuel consumption, that is, when a severe wear of the piston ring occurs, the fuel gas leaks from the gap between the worn piston ring and cylinder liner, which results in the increase in the fuel consumption. Patent Literature 1 says that the lubricating oil composition of Patent

Literature 1 is effective to reduce the wear of the top ring of piston.

[0004] However, on a lubricating oil composition for medium speed four-stroke trunk piston marine diesel engines, there has not been any examination of active approaches for the reduction itself of the fuel consumption, not of passively inhibiting the fuel consumption by inhibiting the increase with time in the fuel consumption.

Citation List

Patent Literatures

[0005] Patent Literature 1: JP 2008-169228 A

SUMMARY OF INVENTION

Technical Problem

[0006] An object of the present invention is to provide a lubricating oil composition for a medium speed trunk piston diesel engine that can reduce the fuel consumption.

Solution to Problem

[0007] A first aspect of the present invention is

a lubricating oil composition for a medium speed trunk piston diesel engine including:

a lubricant base oil being one or more selected from the group consisting of: a mineral or synthetic oil having a kinematic viscosity at 100°C of no less than 3 mm²/s and less than 6 mm²/s, a mineral or synthetic oil having a kinematic viscosity at 100°C of no less than 6 mm²/s and less than 9 mm²/s, and a mineral or synthetic oil having a kinematic viscosity at 100°C of 9 to 13 mm²/s; and

a metallic detergent being a calcium salicylate detergent optionally in combination with a calcium phenate detergent,

wherein the lubricating oil composition has a kinematic viscosity at 100°C of 7.0 to 11.0 mm²/s, a high shear viscosity at 70°C of 7.0 to 20.0 mPa·s, and a base number

determined by perchloric acid method of 7 to 55 mgKOH/g.

[0008] In the present invention, "medium speed trunk piston diesel engine" means a trunk piston diesel engine having a rated speed (rotational speed with maximum continuous output. It is also referred to as continuous maximum rotational speed or continuous rated speed) of 200 rotations/min to 1250 rotations/m. The rated speed is typically 300 rotations/min to 1000 rotations/min.

[0009] As a preferable embodiment of the lubricating oil composition for a medium speed trunk piston diesel engine according to the first aspect of the present invention, an embodiment wherein the lubricating oil composition for a medium speed trunk piston diesel engine according to the first aspect of the present invention further includes: a friction modifier in an amount of 0.2 to 5 mass% on the basis of total mass of the composition may be given. In this embodiment, it is more preferable that the lubricating oil composition for a medium speed trunk piston diesel engine further includes: a viscosity index improver having a PSSI of no more than 30 in an amount of 1 to 10 mass% on the basis of total mass of the composition, wherein the lubricating oil composition has a kinematic viscosity at 100°C of 8.0 to 11.0 mm²/s, a viscosity index of no less than 150, a high shear viscosity at 70°C of 7.0 to 19.0 mPa·s, and a high shear viscosity at 150°C of 2.3 to 3.0 mPa·s. In addition to this, it is especially preferable that the calcium salicylate includes at least a calcium salicylate having a C20 to C30 alkyl group.

[0010] In the present invention, "high shear viscosity at 70°C" and "high shear viscosity at 150°C" are high temperature high shear viscosities (HTHS viscosity) defined in ASTM D 4683, measured at 70°C and 150°C, respectively.

"PSSI" means Permanent Shear Stability Index of polymer calculated on the basis of the data measured by ASTM D 6278-02 (Test Method for Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus), in conformity with ASTM D 6022-01 (Standard Practice for Calculation of Permanent Shear Stability Index).

[0011] As another preferable embodiment of the lubricating oil composition for a medium speed trunk piston diesel engine according to the first aspect of the present invention, an

embodiment wherein the lubricating oil composition for a medium speed trunk piston diesel engine according to the first embodiment of the present invention further includes: a viscosity index improver having a PSSI of no more than 30 in an amount of 1 to 10 mass% on the basis of total mass of the composition, wherein the lubricating oil composition has a kinematic viscosity at 100°C of 8.0 to 11.0 mm²/s, a viscosity index of no less than 150, a high shear viscosity at 70°C of 7.0 to 19.0 mPa·s, and a high shear viscosity at 150°C of 2.3 to 3.0 mPa·s may be given. In this embodiment, it is more preferable that the lubricating oil composition for a medium speed trunk piston diesel engine further includes: a friction modifier in an amount of 0.2 to 5 mass% on the basis of total mass of the composition. In addition to this, it is especially preferable that the calcium salicylate includes at least a calcium salicylate having a C20 to C30 alkyl group.

[0012] A second embodiment of the present invention is A method for lubricating a medium speed trunk piston diesel engine including the step of: lubricating a medium speed trunk piston diesel engine by means of the lubricating oil composition for a medium speed trunk piston diesel engine according to the first aspect of the present invention.

The method for lubricating a medium speed trunk piston diesel engine according to the second aspect of the present invention normally includes a step of supplying the lubricating oil composition according to the first embodiment to a medium speed trunk piston diesel engine.

[0013] The lubricating method according to the second aspect of the present invention may be preferably employed for a medium speed trunk piston diesel engine having a brake mean effective pressure of no less than 1.8 MPa.

Advantageous Effects of Invention

[0014] According to the lubricating oil composition for a medium speed trunk piston diesel engine according to the first aspect of the present invention, and the method for lubricating a medium speed trunk piston diesel engine according to the second aspect of the present invention, it is possible to reduce the fuel consumption of a medium speed trunk piston diesel

engine.

DESCRIPTION OF EMBODIMENTS

[0015] Hereinafter, the present invention will be described in detail. It should be noted that, unless otherwise mentioned, "A to B" regarding numerical values A and B means "A or more and B or less". When the unit of the numerical value A is omitted, the unit given to the numerical value B is applied as the unit of the numerical value A. "or" means a logical sum unless otherwise noted.

10 [0016] <(A) Lubricant base oil>

The lubricant base oil in the lubricating oil composition for a medium speed trunk piston diesel engine of the present invention is one or two or more selected from the group consisting of: a mineral or synthetic oil having a kinematic viscosity at 100°C of no less than 3 mm²/s and less than 6 mm²/s; a mineral or synthetic oil having a kinematic viscosity at 100°C of no less than 6 mm²/s and less than 9 mm²/s; and a mineral or synthetic oil having a kinematic viscosity at 100°C of 9 to 12 mm²/s.

[0017] As the mineral oil, mineral base oils used for normal lubricating oils may be used without particular limitations. Specifically, a product made by purifying a lubricating oil fraction obtained by vacuum distillation of a residue of atmospheric distillation of a crude oil, by one or more treatments of solvent deasphalting, solvent extraction, hydrogenolysis, solvent dewaxing, hydrotreating, and the like; an wax-isomerized mineral oil; a lubricant base oil produced by a method of isomerizing a GTL WAX (Gas To Liquid wax) produced for example by Fisher-Tropsch process, and the like may be given for example.

[0018] The total aromatic content of the mineral base oil is not particularly limited, and preferably no more than 40 mass%, and more preferably no more than 30 mass%. The total aromatic content may be 0 mass%. However, in view of the solubility of additives, the total aromatic content is preferably no less than 1 mass%, more preferably no less than 5 mass%, further preferably no less than 10 mass%, and especially preferably no less than 20 mass%.

If the total aromatic content of the base oil is more than 40 mass%, the oxidation stability is inferior, which is not preferable. The above-described total aromatic content means the content of aromatic fraction measured in conformity with ASTM D2549. The aromatic fraction normally includes: alkyl benzene; alkyl naphthalene; anthracene, phenanthrene, and alkylating substances thereof; compounds in which four or more benzene rings are condensed; and compounds having a hetero aromatic group such as pyridines, quinolines, phenols, and naphthols.

[0019] Sulfur content in the mineral base oil is not particularly limited, and preferably no more than 1 mass%, and more preferably no more than 0.5 mass%. The sulfur content may be 0 mass%, and preferably no less than 0.1 mass%, and more preferably no less than 0.2 mass%. By using a mineral base oil containing a some extent of sulfur, it is possible to increase the solubility of additives.

[0020] As the synthetic oil, synthetic base oils used for normal lubricating oils may be used without particular limitations. Specifically, examples thereof include: polybutene and hydride thereof; oligomers of 1-octene, 1-decene, dodecene, etc., and poly- α -olefins and hydrides thereof, which are mixtures of the above oligomers and the like; diesters such as ditridecyl glutarate, di-2-ethylhexyl adipate, diisodecyl adipate, ditridecyl adipate, and di-2-ethylhexyl sebacate; polyol esters such as trimechylolpropanecaprylate, trimethylolpropanepelargonate, pentaerythritol-2-ethylhexanoate, and pentaerythritolpelargonate; copolymers of dicarboxylic acids such as dibutyl maleate and a C2 to C30 α -olefin; aromatic-based synthetic oils such as alkylnaphthalene, alkylbenzene, and aromatic esters; and mixtures thereof.

[0021] Examples of the mineral or synthetic base oil having a kinematic viscosity at 100°C of no less than 3 mm²/s and less than 6 mm²/s include mineral or synthetic base oils of SAE10. Examples of the mineral or synthetic oil having a kinematic viscosity at 100°C of no less than 6 mm²/s and less than 9 mm²/s include mineral or synthetic base oils of SAE20. Examples of the mineral or synthetic oil having a kinematic viscosity at 100°C of no less than 9 mm²/s and no more than 12 mm²/s include mineral or synthetic base oils of SAE30.

[0022] As a preferable embodiment of the lubricant base oil of the present invention, one or a mixture of two or more selected from the group consisting of the following (A-1) to (A-3) may be given for example.

(A-1) mineral base oil having a saturated component of no less than 90 mass%, sulfur
5 content of no more than 0.03 mass% in terms of an element, and a kinematic viscosity of no less than 80

(A-2) mineral base oil having a saturated component of less than 90 mass%, sulfur content of more than 0.03 mass% in terms of an element, and a kinematic viscosity of no less than 80

(A-3) synthetic base oil

10 The saturated component in the present invention is measured by the method defined in ASTM D 2007-93.

[0023] The kinematic viscosity of the lubricant base oil is not particularly limited. However, in view of obtaining a good viscosity characteristic at a low temperature to a high temperature, the value of the kinematic viscosity is preferably no less than 80, more
15 preferably no less than 85, and further preferably no less than 90. The upper limit of the kinematic viscosity is not particularly limited, and in view of solubility of additives and storage stability, preferably no more than 170, and more preferably no more than 160.

[0024] The evaporation loss of the lubricant base oil is not particularly limited, and in view of oil consumption, preferably no more than 20 mass%, more preferably no more than 16
20 mass%, and especially preferably no more than 10 mass%, as a NOACK evaporation loss (evaporation amount of lubricating oil measured in conformity with ASTM D 5800).

[0025] <(B) Metallic detergent>

The lubricating oil composition of the present invention includes at least a calcium salicylate detergent as a metallic detergent. The lubricating oil composition of the present
25 invention may include a calcium salicylate detergent only as the metallic detergent, and may include a calcium phenate detergent in addition to the calcium salicylate detergent, in combination.

[0026] The alkyl group in alkylsalicylic acid metal salt constituting the calcium salicylate

detergent is a C10 to C40 alkyl group, preferably a C10 to C19 or C20 to C30 alkyl group, and further preferably a C14 to C18 or C20 to C26 alkyl group. In view of having a good low-temperature viscosity characteristic, the alkyl group is desirably a C14 to C18 alkyl group, and in view of having a good soot-dispersing property, desirably a C20 to C30 alkyl group.

5 [0027] Examples of the C10 to C40 alkyl group include decyl group, undecyl group, dodecyl group, tridecyl group, tetradecyl group, pentadecyl group, hexadecyl group, heptadecyl group, octadecyl group, nonadecyl group, icosyl group, henicosyl group, docosyl group, tricosyl group, tetracosyl group, pentacosyl group, hexacosyl group, heptacosyl group, octacosyl group, nonacosyl group, and triacontyl group. The alkyl group may be linear of
10 branched, and may be a primary alkyl group, secondary alkyl group, and tertiary alkyl group. In the present invention, a secondary alkyl group is especially preferable.

[0028] The content of the calcium salicylate detergent in the lubricating oil composition of the present invention is, including a diluent, normally 0.1 to 30 mass%, preferably no less than 1 mass%, more preferably no less than 5 mass%, more preferably no less than 8 mass%,
15 and further preferably no less than 10 mass%. It is preferably no more than 30 mass%, and more preferably no more than 25 mass%. In view of increasing the fuel saving property, the soap content of the detergent is normally 2 to 15 mass%, preferably no less than 3 mass%, and more preferably no less than 4 mass%, on the basis of total mass of the composition. It is preferably no more than 15 mass%, and more preferably no more than 13 mass%. In the
20 present invention, the mass of the soap content of the metallic detergent means the mass as a neutral salt not having had cation exchanges with other additives.

[0029] Examples of the calcium salicylate detergent in the lubricating oil composition of the present invention include a calcium salicylate detergent having a C14 to C18 short chain alkyl group, and a calcium salicylate detergent having a C20 to C30 long chain alkyl group.
25 Either one of the calcium salicylate detergents may be used alone, and both of the calcium salicylate detergents may be used in combination. However, in view of further increasing the fuel-saving property of the lubricating oil composition of the present invention, it is preferable to include a calcium salicylate detergent having a C20 to C30 long chain alkyl

group. When a calcium salicylate detergent having a C20 to C30 long chain alkyl group is included as the metallic detergent in the lubricating oil composition of the present invention, the content thereof is preferably no less than 2.0 mass% and more preferably no less than 3.0 mass% on the basis of total mass of the composition, in view of increasing the fuel-saving property. The upper limit of the content is not particularly limited, and considering the low-temperature fluidity, the mass ratio of the soap content of the calcium salicylate detergent having a C20 to C30 long chain alkyl group to the soap content of total calcium salicylate is preferably no more than 0.8.

[0030] The method for manufacturing the calcium salicylate detergent is not particularly limited, and a known method may be applied. For example, the calcium salicylate detergent may be manufactured by: manufacturing alkylsalicylic acid by a method of alkylating 1 mol of phenol by 1 mol or more of a C10 to C40 olefin such as a polymer or copolymer of ethylene, propylene, butane, etc., preferably a linear α -olefin of ethylene polymer and the like, and thereafter carboxylating the alkylated material by a carbonic acid gas and the like, or a method of alkylating 1 mol of salicylic acid by 1 mol or more of the above-described olefin, preferably the above-described linear α -olefin; and reacting the alkylsalicylic acid and a calcium base such as calcium oxide and calcium hydroxide, or once obtaining an alkali metal salt such as sodium salt and potassium salt, thereafter further substituting the alkali metal ion with a calcium ion. These reactions are normally carried out in a solvent, for example an aliphatic hydrocarbon solvent such as hexane, an aromatic hydrocarbon solvent such as xylene, and a light lubricant base oil.

[0031] The calcium salicylate detergent includes basic salts obtained by a heating of the calcium salicylate (neutral salt) obtained as described above and excess of another calcium salt or calcium base (calcium oxide or calcium hydroxide), under the existence of water, and overbased salts obtained by the reaction of the above-described neutral salt and calcium hydroxide under the existence of carbonic acid gas, boric acid, borate salt, or the like.

[0032] According to the embodiment in which a calcium salicylate detergent only is contained as the metallic detergent in the lubricating oil composition of the present invention,

it is possible to further improve the fuel-saving performance. Therefore, the embodiment is most preferable. On the other hand, it is possible to use another metallic detergent in combination. In this case, in view of the micelle stability, it is preferable to use a phenate detergent, and especially preferable to use a calcium phenate detergent, as the metallic
5 detergent other than the calcium salicylate detergent.

[0033] As the calcium phenate detergent, for example a calcium salt of alkylphenol sulfide obtained by the reaction of sulfur and alkylphenol having at least one C4 to C30, preferably C10 to C18, linear or branched alkyl group, or a calcium salt which is a Mannich reaction product of alkylphenol obtained by the reaction of alkylphenol and formaldehyde is
10 preferably used.

When a calcium phenate detergent is used, the content thereof is not particularly limited, and normally 0.1 to 30 mass%, preferably 0.5 to 10 mass%, and especially preferably 1.0 to 3 mass% on the basis of total mass of the composition.

[0034] When a calcium salicylate detergent and another metallic detergent (for example a
15 calcium phenate detergent) are used in combination in the lubricating oil composition of the present invention, the mass ratio of the total soap content of the calcium salicylate detergent to the total soap content of the metallic detergent (calcium salicylate soap content / total soap content of metallic detergent) is preferably no less than 0.6, and more preferably no less than 0.7. The upper limit of the mass ratio is not particularly limited, and as described above, it is
20 possible to have an embodiment in which only a calcium salicylate detergent is contained as the metallic detergent.

[0035] The base number of the metallic detergent in the lubricating oil composition of the present invention is not particularly limited, as long as the base number of the lubricating oil composition is within the desirable range, which is described later. However, the base
25 number is normally 0 to 500 mgKOH/g, and preferably 20 to 450 mgKOH/g.

[0036] The total content of the metallic detergent in the lubricating oil composition of the present invention is, including a diluent, 0.1 to 30 mass%, preferably no less than 1 mass%, more preferably no less than 5 mass%, further preferably no less than 8 mass%, and

especially preferably no less than 10 mass%,. The total content is preferably no more than 30 mass%, and more preferably no more than 25 mass%.

[0037] <(C) Friction modifier>

It is preferable that the lubricating oil composition of the present invention includes a friction modifier. As the friction modifier in the lubricating oil composition of the present invention, a known ashless friction modifier and molybdenum-based friction modifier may be used without particular limitations.

[0038] Examples of the ashless friction modifier include aliphatic amine compounds, aliphatic imide compounds, fatty acid esters, fatty acid amides, fatty acids, aliphatic alcohols, aliphatic ethers, aliphatic ureas, and aliphatic hydrazidos, having at least one C6 to C30 hydrocarbon group. The above hydrocarbon group is preferably an alkyl group or alkenyl group, and further preferably a linear alkyl group or linear alkenyl group. The carbon number of the above hydrocarbon group is preferably no less than 10, more preferably no less than 12, and preferably no more than 24.

[0039] Examples of the aliphatic amine compounds include: aliphatic monoamine having a C6 to C30 linear or branched alkyl group or alkenyl group, preferably linear alkyl group or alkenyl group; aliphatic polyamine having a C6 to C30 linear or branched alkyl group or alkenyl group, preferably linear alkyl group or alkenyl group; and alkylene oxide adducts of these aliphatic amines.

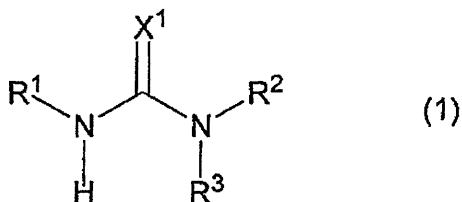
Examples of the fatty acid esters include an ester of a C7 to C31 linear or branched fatty acid, preferably linear fatty acid, and an aliphatic monohydric alcohol or aliphatic polyhydric alcohol. More specific examples include an ester of a polyhydric alcohol such as glycerin and sorbitan, and a fatty acid such as oleic acid (typical example: glycerol mono-oleate).

Examples of the fatty acid amides include an amide of a C7 to C31, preferably C12 to C24, more preferably C16 to C20 linear or branched fatty acid, preferably linear fatty acid, and an aliphatic monoamine or aliphatic polyamine.

Examples of another preferable group of ashless friction modifier include an

aliphatic (thio)urea compound shown by the following general formula (1) and acid modified material thereof.

[0040]

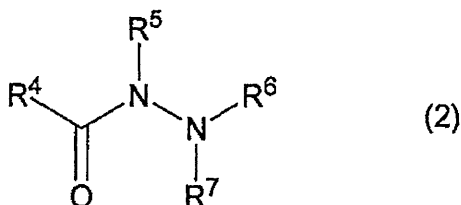


5 [0041] In the general formula (1), R¹ is a C1 to C30 aliphatic hydrocarbon group, preferably C10 to C30 aliphatic hydrocarbon group, and more preferably C12 to C24 alkyl group or alkenyl group. R² and R³ independently are a C1 to C30 aliphatic hydrocarbon group or hydrogen, preferably C1 to C10 aliphatic hydrocarbon group or hydrogen, more preferably C1 to C4 aliphatic hydrocarbon group or hydrogen, and especially preferably hydrogen. X¹ is
10 oxygen or sulfur, and preferably oxygen.

[0042] Especially preferable examples of the nitrogen-containing compound represented by the general formula (1) include an urea compound wherein X¹ is oxygen, R¹ is a C12 to C24 alkyl group or alkenyl group, R² and R³ are hydrogen, and an acid modified material thereof. Specifically, dedecylurea, tridecylurea, tetradecylurea, pentadecylurea, hexadecylurea,
15 heptadecylurea, octadecylurea, oleylurea, and acid modified materials thereof may be given. Among them, oleylurea (C₁₈H₃₅-NH-C(=O)-NH₂) and acid modified material thereof (e.g. boric acid modified material) may be especially preferably used.

[0043] Examples of another preferable group of ashless friction modifier include a hydrazide compound represented by the following general formula (2) and acid modified
20 material thereof.

[0044]



[0045] In the general formula (2), R^4 is a C1 to C30 aliphatic hydrocarbon group, preferably C10 to C30 aliphatic hydrocarbon group, and more preferably C12 to C24 alkyl group or alkenyl group. R^5 to R^7 independently are a C1 to C30 aliphatic hydrocarbon group or hydrogen, preferably C1 to C10 hydrocarbon group or hydrogen, more preferably C1 to C4 aliphatic hydrocarbon group or hydrogen, and further preferably hydrogen.

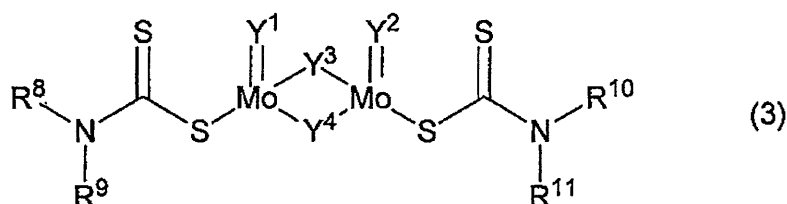
[0046] Especially preferable examples of the hydrazide compound represented by the general formula (2) include a hydrazide compound wherein R^4 is a C12 to 24 alkyl group or alkenyl group, and R^5 , R^6 and R^7 are hydrogen, and an acid modified material thereof. Specifically, dodecanoic acid hydrazide, tridecanoic acid hydrazide, tetradecanoic acid hydrazide, pentadecanoic acid hydrazide, hexadecanoic acid hydrazide, heptadecanoic acid hydrazide, octadecanoic acid hydrazide, oleic acid hydrazide, erucic acid hydrazide, and acid modified materials thereof (e.g. boric acid modified material) may be given. Among them, oleic acid hydrazide ($C_{17}H_{33}-C(=O)-NH-NH_2$) and acid modified material thereof, and erucic acid hydrazide ($C_{21}H_{41}-C(=O)-NH-NH_2$) and acid modified material thereof may be especially preferably used.

[0047] In the present invention, among the above-listed ashless friction modifiers, one or more ashless friction modifier selected from the group consisting of a fatty acid ester, fatty acid amide, aliphatic urea and acid modified material thereof, and aliphatic hydrazide and acid modified material thereof may be preferably used. Examples of preferable combinations include a combination of a fatty acid ester-based ashless friction modifier and an aliphatic amide-based ashless friction modifier (e.g. combination of glycerol mono-oleate and oleylurea).

[0048] Examples of the molybdenum-based friction modifier include molybdenum dithiocarbamate, molybdenum dithiophosphate, organic molybdenum compounds such as molybdenum-amine complex.

As the molybdenum dithiocarbamate, a compound represented by the following general formula (3) may be used for example.

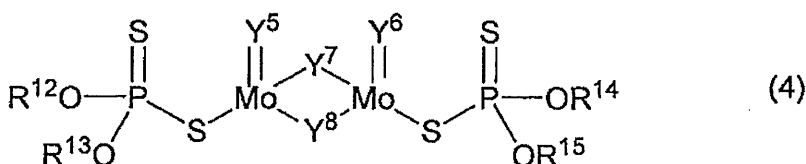
[0049]



[0050] In the above general formula (3), R⁸ to R¹¹, the same or different, are a C2 to C24 alkyl group or C6 to C24 (alkyl)aryl group, preferably C4 to C13 alkyl group or C10 to C15 (alkyl)aryl group. The alkyl group may be a primary alkyl group, secondary alkyl group, and tertiary alkyl group, and may be linear or branched. It is noted “(alkyl)aryl group” means “aryl group or alkylaryl group”. In the alkylaryl group, substitution of the alkyl group on the aromatic ring may be in any position. Y¹ to Y⁴ independently are a sulfur atom or oxygen atom.

[0051] As the molybdenum dithiophosphate, a compound represent by the following general formula (4) may be used for example.

[0052]



[0053] In the above general formula (4), R¹² to R¹⁵, the same or different, are a C2 to C30 alkyl group or C6 to C18 (alkyl)aryl group. The carbon number of the alkyl group is preferably 5 to 18, and more preferably 5 to 12. The carbon number of the (alkyl)aryl group is preferably 10 to 15. Y⁵ to Y⁸ independently are a sulfur atom or oxygen atom. The alkyl group may be a primary alkyl group, secondary alkyl group, and tertiary alkyl group, and may be linear or branched. In the alkylaryl group, substitution of the alkyl group in the aromatic ring may be in any position.

[0054] As the molybdenum-based friction modifier, molybdenum dithiocarbamate may be especially preferably used, in view of making it possible to improve the wear resistant property even when the viscosity of the lubricating oil composition is low.

[0055] When these friction modifiers are contained in the lubricating oil composition of the

present invention, the total content thereof is preferably 0.2 to 5 mass% on the basis of total mass of the composition. The lower limit is more preferably no less than 0.5 mass%, and the upper limit is more preferably no more than 2.0 mass% and further preferably no more than 1.0 mass%.

5 It is preferable that the lubricating oil composition of the present invention contains a molybdenum-based friction modifier. The content thereof is, as molybdenum amount, preferably 100 to 1500 mass ppm, and especially preferably 200 to 1000 mass ppm, on the basis of total mass of the composition. The lubricating oil composition may include a molybdenum-based friction modifier and an ashless friction modifier in combination.

10 [0056] <(D) Viscosity index improver>

It is preferable that the lubricating oil composition of the present invention includes a viscosity index improver. The viscosity index improver in the lubricating oil composition of the present invention is not particularly limited, and a known viscosity index improver such as a non-dispersive or dispersive ester group-containing viscosity index improver,
15 non-dispersive or dispersive poly(meth)acrylate-based viscosity index improver, styrene-diene hydrogenated copolymer, non-dispersive or dispersive ethylene- α -olefin copolymer or hydride thereof, polyisobutylene or hydride thereof, styrene-maleic anhydride acid copolymer, polyalkyl styrene, and (meth)acrylate-olefin copolymer may be used.

Among them, for the lubricating oil composition of the present invention, an olefin
20 copolymer such as ethylene- α -olefin copolymer or hydride thereof may be preferably used as a viscosity index improver.

[0057] As the viscosity index improver in the lubricating oil composition of the present invention, a viscosity index improver having a PSSI of no more than 30 may be preferably used. For example, among the above-listed viscosity index improvers, a viscosity index
25 improver having a PSSI of no more than 30 may be used. Here, PSSI means Permanent Shear Stability Index of polymer calculated on the basis of the data measured by ASTM D 6278-02 (Test Method for Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus) in conformity with ASTM D 6022-01 (Standard Practice for

Calculation of Permanent Shear Stability Index). PSSI of the viscosity index improver is preferably no more than 25. A viscosity index improver having a PSSI of no more than the above upper limit has a high shear stability. Therefore, it is possible to further improve the fuel saving property by reducing the initial kinematic viscosity of the lubricating oil composition. If PSSI is more than 30, the lubricating oil composition is sheared at the power take-off gear and the viscosity gets deteriorated, and a seizure might occur due to the deterioration of oil film formation performance. In view of the effect of viscosity index improvement, PSSI of the viscosity index improver is preferably no less than 5.

[0058] The weight average molecular weight of the viscosity index improver in the lubricating oil composition of the present invention is normally 10,000 to 400,000, preferably no more than 380,000, and more preferably no more than 360,000 in view of shear stability and solubility, and preferably no less than 50,000, and more preferably no less than 100,000 in view of the effect of viscosity index improvement.

[0059] When a viscosity index improver is contained in the lubricating oil composition of the present invention, the content thereof is normally 1.0 to 15.0 mass%, preferably 1.5 to 10.0 mass%, and more preferably 2.0 to 9.0 mass%, on the basis of total mass of the composition. If the content of the viscosity index improver is less than 1.0 mass%, the improvement effect of the viscosity is not enough, and if the content is more than 15.0 mass%, there is a possibility of deterioration in shear stability and deterioration in cleanliness of the composition.

[0060] <Other additives>

The lubricating oil composition of the present invention may further include, in addition to the above-described lubricant base oil and metallic detergent, at least one selected from the group consisting of an ashless dispersant, wear inhibitor or extreme pressure agent, antioxidant, pour point depressant, metal deactivator, corrosion inhibitor, antirust agent, anti-emulsifier, and defoamer.

[0061] As the ashless dispersant, a known ashless dispersant used for lubricating oils may be used without particular limitations. Examples thereof include a nitrogen-containing

compound having at least one C40 to C400 linear or branched alkyl group or alkenyl group in the molecular, and a derivative thereof.

Examples of the nitrogen-containing compound include succinimide, benzylamine, polyamine, and Mannich base. Examples of the derivative thereof include derivatives
5 produced by the action of a boron compound such as boric acid and borate salt, a phosphorus compound such as (thio)phosphoric acid and (thio)phosphoric acid salt, an organic acid, hydroxyl(poly)oxyalkylenecarbonate, or the like with the nitrogen-containing compound. In the present invention, one or two or more optionally selected from the above may be blended.

As the ashless dispersant, a mono type and/or bis type succinimide ashless dispersant,
10 especially a bis type succinimide ashless dispersant may be preferably used, in view of having a high-temperature cleaning property. The succinimide ashless dispersant may include boron, or may not include boron. In view of the seizure resistance property, a succinimide ashless dispersant including boron is especially preferable.

When the lubricating oil composition of the present invention includes an ashless
15 dispersant, the content thereof is not particularly limited, and for example it may be 0.1 to 5 mass% on the basis of total mass of the composition. In view of securing water separation property for washing treatments with water by an oil purifying device of the diesel engine, the content is preferably less than 3 mass% and more preferably less than 2 mass% on the basis of total mass of the composition, and preferably less than 0.05 mass% and more preferably less
20 than 0.04 mass% in terms of nitrogen amount. It is also possible to have a lubricating oil composition not including an ashless dispersant.

[0062] As the wear inhibitor or extreme pressure agent, a known wear inhibitor or extreme pressure agent may be used without particular limitations. For example, sulfur-based, phosphorus-based, or sulfur-phosphorus based extreme pressure agent may be used.
25 Specifically, zinc dithiophosphate, phosphorous esters, thiophosphorous esters, dithiophosphorous esters, trithiophosphorous esters, phosphoric esters, thiophosphoric esters, dithiophosphoric esters, trithiophosphoric esters, amine salts thereof, metal salts thereof, derivatives thereof, dithiocarbamates, disulfides, polysulfides, olefin sulfides, fat sulfides, and

the like may be given for example. When these wear inhibitors or extreme pressure agents are contained in the lubricating oil composition of the present invention, the content thereof is normally 0.01 to 5 mass% on the basis of total mass of the composition.

[0063] As the antioxidant, a known antioxidant may be used without particular limitations.

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

10 [0064] As the pour point depressant, a known pour point depressant such as polymethacrylate-based polymers may be used without particular limitations, depending on the characteristics of the lubricant base oil to be used. When a pour point depressant is contained in the lubricating oil composition of the present invention, the content thereof is normally 0.01 to 1 mass% on the basis of total mass of the composition.

15 [0065] As the corrosion inhibitor, a known corrosion inhibitor such as benzotriazole-based, tolyltriazole-based, thiadiazole-based, and imidazole-based compounds may be used without particular limitations. When these corrosion inhibitors are contained in the lubricating oil composition of the present invention, the content thereof is normally 0.005 to 5 mass% on the basis of total mass of the composition.

20 [0066] As the antirust agent, a known antirust agent such as petroleum sulfonate, alkylbenzene sulfonate, dinonylnaphthalene sulfonate, alkenylsuccinic acid ester, and polyhydric alcohol ester may be used without particular limitations. When these antirust agents are contained in the lubricating oil composition of the present invention, the content thereof is normally 0.005 to 5 mass% on the basis of total mass of the composition.

25 [0067] As the anti-emulsifier, a known anti-emulsifier for example a polyalkylene glycol-based non-ionic surfactant agent, such as polyoxyethylenealkylether, polyoxyethylenealkylphenylether, and polyoxyethylenealkylnaphthylether, may be used without particular limitations. When these anti-emulsifiers are contained in the lubricating

oil composition of the present invention, the content thereof is normally 0.005 to 5 mass% on the basis of total mass of the composition.

[0068] As the metal deactivator, a known metal inactivator such as imidazoline, pyrimidine derivative, alkylthiadiazole, mercaptobenzothiazole, benzotriazole and derivative thereof, 1,3,4-thiadiazolepolysulfide, 1,3,4-thiadiazolyl-2,5-bisdialkyldithiocarbamate, 2-(alkyldithio)benzoimidazole, and β -(o-carboxybenzylthio)propionitrile may be used without particular limitations. When these metal inactivators are contained in the lubricating oil composition of the present invention, the content thereof is normally 0.005 to 1 mass% on the basis of total mass of the composition.

[0069] As the defoamer, a known defoamer such as silicone, fluorosilicol, and fluoroalkylether may be used without particular limitations. When these defoamers are contained in the lubricating oil composition of the present invention, the content thereof is normally 0.0005 to 1 mass% on the basis of total mass of the composition.

[0070] <Lubricating oil composition>

The kinematic viscosity at 100°C of the lubricating oil composition of the present invention is 7.0 to 11.0 mm²/s, preferably 8.0 to 11.0 mm²/s, and more preferably no less than 8.0 mm²/s and less than 10.0 mm²/s. If the kinematic viscosity of the composition is less than 7.0 mm²/s, it gets difficult to secure the oil film thickness and oil pressure required for the reliability of the medium speed diesel engine. If the kinematic viscosity of the composition is more than 11.0 mm²/s, it gets difficult to provide the reduction effect of the fuel consumption. It is noted that the kinematic viscosity at 100°C mentioned here means the kinematic viscosity at 100°C defined in ASTM D 445.

[0071] The high shear viscosity at 70°C of the lubricating oil composition of the present invention is 7.0 to 20.0 mPa·s, preferably no more than 19 mPa·s, and more preferably no more than 17 mPa·s. The viscosity is preferably no less than 8 mPa·s, and more preferably no less than 9 mPa·s. The high shear viscosity at 70°C in the present invention means a high temperature high shear viscosity (HTHS viscosity) at 70°C measured with the temperature changed, on the basis of the method defined in ASTM D 4683. If the high shear viscosity at

70°C is less than 7.0 mPa·s, the lubrication property might be insufficient, and if the high viscosity at 70°C is more than 20.0 mPa·s, it is difficult to sufficiently improve the fuel-saving property.

[0072] The high shear viscosity at 150°C of the lubricating oil composition of the present invention is not particularly limited as long as the high shear viscosity at 70°C is within the above-described range, and preferably 2.3 to 3.3 mPa·s, and more preferably 3.0 mPa·s. It is preferably no less than 2.6. In the present invention, the high shear viscosity at 150°C means a high temperature high shear viscosity (HTHS viscosity) at 150°C defined in ASTM D 4683. By having a high shear viscosity at 150°C in the above-described range, it is possible to further improve the fuel-saving property while keeping the lubrication property.

[0073] The base number of the lubricating oil composition of the present invention needs to be no less than 7 mgKOH/g, preferably no less than 9 mgKOH/g, and more preferably no less than 10 mgKOH/g, in order to provide a good high-temperature cleaning property and acid neutralizing performance even when a high-sulfur fuel containing asphaltene is used. In addition, in order to prevent bore polishing and scuffing of the liner due to the accumulation of excess ash on the piston top land, the base number needs to be no more than 55 mgKOH/g, and preferably no more than 50 mgKOH/g.

The base number mentioned here means the base number determined by perchloric acid method measured by ASTM D 2896.

[0074] The sulfated ash content of the lubricating oil composition of the present invention is not particularly limited, and preferably no less than 0.9 mass%, more preferably no less than 1.2 mass%, and preferably no more than 7.0 mass%, and more preferably no more than 6.5 mass%. The sulfated ash content mentioned here is the value measured by the method defined in 5. "Determination of sulfated acid" of JIS K2272, and is mainly from metal-containing additives.

Examples

[0075] Hereinafter the present invention will be further specifically described based on

Examples and Comparative Examples. It is noted that the present invention is not limited to these Examples.

[0076] <Examples 1 to 9 and Comparative Examples 1 and 2>

As shown in Table 1, lubricating oil compositions of the present invention (Examples
5 1 to 9), and lubricating oil compositions for comparison (Comparative Examples 1 and 2)
were each prepared. In the table, "inmass%" means mass% on the basis of total mass of the
base oil, and "mass%" means mass% on the basis of total mass of the composition.

[0077]

[Table 1]

[0078] (Evaluation of fuel consumption reduction performance (1): WD300 engine fuel consumption test)

On each of Examples 1 to 9 and Comparative Examples 1 and 2, the fuel consumption when the composition was used as an engine oil of a medium speed four-stroke trunk piston diesel engine was measured. As a medium speed four-stroke trunk piston marine diesel engine, WD300 manufactured by Ricardo PLC (bore 135 mm × stroke 152 mm, single cylinder, mean effective pressure 2.5 MPa, rated speed 1200 rpm) was used, and as a fuel, a Grade 1 diesel defined in JIS K2204 (sulfur content: less than 0.0010 mass%) was used. The engine was operated at a constant speed for one hour under the conditions of 1200 rpm of engine speed and 54 kW of load. The fuel consumption during the operation was converted to a value per unit output (g/kWh). The results are shown in Table 1.

[0079] (Evaluation of fuel consumption reduction performance (2): 3DK-20 engine fuel consumption test)

On each of the lubricating oil compositions of Examples 2, 4 and 9 and Comparative Example 1, the fuel consumption when the composition was used as an engine oil of a four-stroke medium speed trunk piston marine diesel engine was measured. As the four-stroke medium speed trunk piston marine diesel engine, 3DK-20 manufactured by Daihatsu Motor Co., Ltd. (bore 200 mm × stroke 300 mm, three cylinders, mean effective pressure 2.1 MPa, maximum continuous output 455 kW, rated speed 900 rpm) was used, and as the fuel, Grade 1 No. 1 heavy oil (sulfur: no more than 0.5 mass%) defined in JIS K2205 was used. In the measurement with 85% load, the engine was operated at a constant speed for 1 hour, under the conditions of 890 rpm of engine speed and 280 kW of load. In the measurement with 50% load, the engine was operated at a constant speed for 1 hour, under the conditions of 890 rpm of engine speed and 163 kW of load. Each fuel consumption was converted to the value per unit work (g/kWh). The results are shown in Table 1.

[0080] (Evaluation of load resistance performance: Falex test)

On each of the lubricating oil compositions of Examples 2, 4 and 9 and Comparative Example 2, the load resistance performance was evaluated by A method wherein the load was

continuously increased until a seizure occurred, and B method wherein the load was gradually increased, by means of a Falex testing machine. The rotational speed of the pin was 290 rpm in each of A and B methods. The test of A method was carried out at 52°C, and the test of B method was carried out at a room temperature. The load (1bf) when a seizure occurred
5 is shown in Table 1.

[0081] (Evaluation of wear resistance property (1): Shell high speed four ball test)

On each of the lubricating oil compositions of Examples 2, 4 and 9 and Comparative Example 2, the wear resistance property was evaluated by means of a shell four ball friction testing machine, in conformity with JPI-5S-32-90. The testing machine was operated for 1
10 hour under the conditions of 294 N (30 kgf) of load, 75°C of oil temperature, and 1800 rpm of rotational speed, thereafter the diameters of wear marks created at the contact points of balls were measured. The results are shown in Table 1.

[0082] (Evaluation of wear resistance property (2): TE77 reciprocating friction testing machine (manufactured by Phoenix Tribology Ltd.)

15 On each of the lubricating oil compositions of Examples 2, 4 and 9 and Comparative Example 2, the wear resistance property was evaluated by means of a TE77 reciprocating friction testing machine. A ball-on-plate method by means of a test ball of 6 mm in diameter was applied as the contact form. The materials of the test ball and the test plate corresponded to SUJ-2. The testing machine was operated for 1 hour, under the conditions
20 of 150°C of temperature of lubricating oil, 200N of load, 15 mm of double amplitude, and 20 Hz of vibration frequency. Thereafter the diameter of the wear mark created at the contact point of the ball was measured. The results are shown in Table 1.

[0083] (Evaluation result)

As is seen from Table 1, all of the lubricating oil compositions of Examples 1 to 9
25 were able to reduce the fuel consumption in WD300 engine fuel consumption test, compared to the compositions of Comparative Examples 1 and 2 each having a kinematic viscosity at 100°C and a high shear viscosity at 70°C out of the ranges of the present invention.

The compositions of Examples 2 to 5 and 7 to 9 containing a friction modifier

showed a further better fuel-saving property than that of the composition of Example 1 not containing a friction modifier.

5 The compositions of Examples 6 to 9 including the viscosity index improver of no more than 30 in PSSI, each having a kinematic viscosity at 100°C of 8.0 to 11.0 mm²/s, a viscosity index of no less than 150, and a high shear viscosity at 70°C of 7.0 to 19.0 mPa·s showed good fuel-saving properties in WD300 engine fuel consumption test even when a friction modifier was not contained (Example 6). When the compositions contained a friction modifier (Examples 7 to 9), they showed further better fuel-saving properties.

10 In 3DK-20 engine fuel consumption test carried out on the compositions of Examples 2, 4 and 9, the fuel consumption reduction effect with 50% load was higher than the fuel consumption reduction effect with 85% load. From this result, it is figured out that the lubricating oil composition of the present invention is especially effective for reducing the fuel consumption at an operation with medium-low load.

15 All of the compositions of Examples 2, 4 and 9 had load resistance properties and wear resistance properties which favorably compare with that of the composition of Comparative Example 2.

[0084] From the above results, it was shown that it was possible to reduce the fuel consumption of a medium speed trunk piston diesel engine, according to the lubricating oil composition of the present invention.

20

Industrial applicability

[0085] The lubricating oil composition for a medium speed trunk piston diesel engine of the present invention and the method for lubricating a medium speed trunk piston diesel engine using the composition may be employed preferably for lubrication of medium speed trunk piston diesel engines for ships and power generators, and especially preferably for lubrication of medium speed trunk piston marine diesel engines.

25

CLAIMS

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

a lubricant base oil being one or more selected from the group consisting of: a mineral or synthetic oil having a kinematic viscosity at 100°C of no less than 3 mm²/s and less than 6 mm²/s, and a mineral or synthetic oil having a kinematic viscosity at 100°C of no less than 6 mm²/s and less than 9 mm²/s;

a metallic detergent being a calcium salicylate detergent optionally in combination with a calcium phenate detergent; and

an olefin copolymer viscosity index improver having a PSSI of no more than 30 in an amount of 1 to 10 mass% on the basis of total mass of the composition,

wherein the lubricating oil composition has a kinematic viscosity at 100°C of 8.0 to 11.0 mm²/s, a viscosity index of no less than 150, a high shear viscosity at 70°C of 12.3 to 19.0 mPa·s, a high shear viscosity at 150°C of 2.3 to 3.0 mPa·s, and a base number determined by perchloric acid method of 7 to 55 mgKOH/g.

2. The lubricating oil composition for a medium speed trunk piston diesel engine according to claim 1,

wherein the olefin copolymer viscosity index improver comprises an ethylene- α -olefin copolymer or a hydrogenated product thereof.

3. The lubricating oil composition for a medium speed trunk piston diesel engine according to claim 1 or 2, further comprising:

a friction modifier in an amount of 0.2 to 5 mass% on the basis of total mass of the composition.

4. The lubricating oil composition for a medium speed trunk piston diesel engine according to claim 3,

wherein the calcium salicylate comprises at least a calcium salicylate having a C20 to C30 alkyl group.

5. A method for lubricating a medium speed trunk piston diesel engine comprising the step of:

lubricating a medium speed trunk piston diesel engine by means of the lubricating oil composition for a medium speed trunk piston diesel engine according to any one of claims 1 to 4.

6. The method for lubricating a medium speed trunk piston diesel engine according to claim 5,

wherein a brake mean effective pressure of the medium speed trunk piston diesel engine is no less than 1.8 MPa.