

DESCRIPTION

LUBRICATING OIL COMPOSITION FOR TRUNK PISTON DIESEL ENGINE

5

TECHNICAL FIELD

[0001] The present invention relates to a lubricating oil composition for trunk piston diesel engines.

10

BACKGROUND ART

[0002] Fuel including an asphaltene component such as A heavy oil or C heavy oil is often used as fuel for a trunk piston diesel engine for ships. Since the diesel engine is contaminated by the asphaltene component stemming from the fuel, however, a large amount of a detergent is typically blended into the lubricating oil (see Patent Literature 1). Therefore, in lubricating oil compositions for trunk piston diesel engines for ships, solubility is required for the detergent added in a large amount, and solubility is required for non-combusted asphaltene, combustion-generated resin, and the like that are mixed in from the fuel. In particular, solubility of non-combusted asphaltene is important for preventing generation of black sludge, which may lead to damage to the piston.

[0003] The base oils used in a conventional lubricating oil composition for trunk piston diesel engines are mainly manufactured by separating gasoline or a light oil component from crude oil by distillation, further subjecting the resulting atmospheric distillation residue to reduced-pressure distillation, bringing out the necessary viscosity fraction, and refining the result. These base oils are classified in group I under the API base oil categorization.

[0004] Since the sulfur content and the aromatic content included in the base oil adversely affect the oxidative stability of the base oil, the above-mentioned residue has in recent years started to be subjected to hydrocracking to manufacture a base oil with an extremely small sulfur content and aromatic content.

[0005] Petroleum-based wax, which is a by-product when manufacturing wax or base oil manufactured by the Fischer-Tropsch process or the like, is

also subjected to hydrocracking to manufacture base oils with an extremely high viscosity index. These base oils manufactured by hydrocracking are classified in group II or III under the API base oil categorization.

[0006] During the refining process of the former base oils (group I), many processes are used to employ a solvent such as furfural, phenol, methylpyrrolidone, or the like to selectively extract and remove unstable compounds centering on the aromatic content. By contrast, in the manufacturing method of the latter base oils, the aromatic content in the base oils is extremely low, and there is nearly no need to undergo the above-described solvent refining processes. Therefore, the relative amount of base oil manufactured by undergoing a solvent refining process is declining.

[0007] When using heavy fuel, a polycyclic aromatic such as asphaltene is included in the heavy fuel, and in the case of internal combustion, the polycyclic aromatic mixes into the lubricating oil as a portion of non-combusted material. This non-combusted material dissolves relatively easily in group I base oil yet has poor solubility in group II base oil and group III base oil. Therefore, the non-combusted material accumulates in the lubricating oil channel and the lubricated portion and also tends to suffer oxidation degradation, thus forming deposits even more easily.

CITATION LIST

Patent Literature

[0008] PTL 1: JP 2002-515933 A

SUMMARY OF INVENTION

(Technical Problem)

[0009] Based on these circumstances, as a lubricating oil composition for trunk piston diesel engines that use heavy fuel, the present invention provides a lubricating oil composition for trunk piston diesel engines that generates few deposits even when using a group II or group III base oil and that has excellent high temperature detergency.

(Solution to Problem)

[0010] As a result of intensive research in order to resolve the above problems, the inventors discovered that adding an extract that is a by-product

yielded during solvent refining or a group I base oil to a group II and/or group III base oil can contribute to resolving the above problems, thereby completing the present invention.

[0011] A lubricating oil composition for a trunk piston diesel engine
5 according to the present invention comprises:

a base oil with a kinematic viscosity at 100°C of 5 mm²/s to 16 mm²/s including:

(A) a mineral lubricating base oil with a saturated hydrocarbon content of 90% by mass or more, a sulfur content of 0.03% by mass or less in terms of element content, a viscosity index of 80 or more, and a kinematic
10 viscosity at 100°C of 3 mm²/s to 35 mm²/s; and

(B) 5% by mass or more, in terms of total content of the base oil, of an extract (B1) yielded as a by-product during solvent refining in a mineral lubricating base oil manufacturing process, the extract (B1) containing 15% or
15 more of aromatic hydrocarbon compounds (%C_A) according to a composition analysis method stipulated in ASTM D2140, or 20% by mass or more, in terms of total content of the base oil, of a mineral lubricating base oil (B2) with a saturated hydrocarbon content of less than 90% by mass, a sulfur content exceeding 0.03% by mass in terms of element content, and a kinematic
20 viscosity at 100°C of 30 mm²/s or more,

the base oil being compounded with:

(D) a metallic detergent; and

(E) an ashless dispersant.

[0012] The lubricating oil composition for a trunk piston diesel engine
25 according to the present invention preferably comprises:

a base oil with a kinematic viscosity at 100°C of 5 mm²/s to 16 mm²/s including:

(A) a mineral lubricating base oil with a saturated hydrocarbon content of 90% by mass or more, a sulfur content of 0.03% by mass or less in terms of element content, a viscosity index of 80 or more, and a kinematic
30 viscosity at 100°C of 3 mm²/s to 35 mm²/s;

(B) 5% by mass or more, in terms of total content of the base oil, of an extract (B1) yielded as a by-product during solvent refining in a mineral lubricating base oil manufacturing process, the extract (B1) containing 15% or

more of aromatic hydrocarbon compounds (%C_A) according to a composition analysis method stipulated in ASTM D2140; and

(C) a polybutene-based synthetic oil or a hydride thereof,
the base oil being compounded with:

5 (D) a metallic detergent; and

(E) an ashless dispersant.

[0013] In the lubricating oil composition for a trunk piston diesel engine according to the present invention, component (B) is preferably an extract with a PCA content of less than 3% by mass.

10 [0014] In the lubricating oil composition for a trunk piston diesel engine according to the present invention, component (B) is preferably an extract with an MI value of less than 1.0, a benzo[a]pyrene content of 1 mg/kg or less, and a particular aromatic compound (PAH) content of 10 mg/kg or less.

[0015] In the lubricating oil composition for a trunk piston diesel engine
15 according to the present invention, a bicyclic or higher aromatic content included in the base oil is preferably 2% by mass or more.

[0016] In the lubricating oil composition for a trunk piston diesel engine according to the present invention, kinematic viscosity at 100°C is preferably 5.6 mm²/s to 16.3 mm²/s, and a base number is preferably 9 mg KOH/g to 55
20 mg KOH/g (perchloric acid method).

(Advantageous Effect of Invention)

[0017] According to the present invention, as a lubricating oil composition for trunk piston diesel engines that use heavy fuel, it is possible to provide a lubricating oil composition for trunk piston diesel engines that generates few
25 deposits even when using a group II or group III base oil.

DESCRIPTION OF EMBODIMENTS

[0018] The present invention is described below in detail. The base oil in the lubricating oil composition for trunk piston diesel engines according to the
30 present invention (also referred to below simply as a lubricating oil composition) has a kinematic viscosity at 100°C of 5 mm²/s to 16 mm²/s and includes:

(A) a mineral lubricating base oil with a saturated hydrocarbon content of 90% by mass or more, a sulfur content of 0.03% by mass or less in terms of

element content, a viscosity index of 80 or more, and a kinematic viscosity at 100°C of 3 mm²/s to 35 mm²/s;

(B) 5% by mass or more, in terms of total content of the base oil, of an extract (B1) yielded as a by-product during solvent refining in a mineral lubricating base oil manufacturing process, the extract (B1) containing 15% or more of aromatic hydrocarbon compounds (%C_A) according to a composition analysis method stipulated in ASTM D2140, or 20% by mass or more, in terms of total content of the base oil, of a mineral lubricating base oil (B2) with a saturated hydrocarbon content of less than 90% by mass, a sulfur content exceeding 0.03% by mass in terms of element content, and a kinematic viscosity at 100°C of 30 mm²/s or more. In the base oil in the lubricating oil composition according to the present invention, when 5% by mass or more, in terms of total content of the base oil, of the extract (B1) yielded as a by-product during solvent refining in a mineral lubricating base oil manufacturing process is included as component (B), the extract (B1) containing 15% or more of aromatic hydrocarbon compounds (%C_A) according to a composition analysis method stipulated in ASTM D2140, then (C) a polybutene-based synthetic oil or a hydride thereof is preferably further included.

[0019] Component (A) is a mineral lubricating base oil with a saturated hydrocarbon content of 90% by mass or more, a sulfur content of 0.03% by mass or less in terms of element content, a viscosity index of 80 or more, and a kinematic viscosity at 100°C of 3 mm²/s to 35 mm²/s, and is classified as group II or group III in accordance with base oil classification by the American Petroleum Institute (API). In the present invention, the saturated hydrocarbon content denotes the value measured by ASTM D-2007.

[0020] The manufacturing method of the above mineral lubricating base oil is not particularly limited, yet typically, the atmospheric residual oil yielded by subjecting crude oil to atmospheric distillation is subjected to desulfurization and hydrocracking, and then to fractional distillation to a set viscosity grade. Alternatively, the residual oil is subjected to solvent dewaxing or catalytic dewaxing, and as necessary, further subjected to solvent extraction and hydrogenated to yield the base oil.

[0021] Component (A) also includes the case of a petroleum wax

isomerization lubricating base oil yielded by hydroisomerization of petroleum wax that is a by-product yielded during a dewaxing process in a process for manufacturing base oil performed in recent years, whereby the atmospheric distillation residual oil is further subjected to reduced-pressure distillation and to fractional distillation to the necessary viscosity grade, and then after
5 undergoing processes such as solvent refining, hydrotreating, and the like, the result is subjected to solvent dewaxing. Additionally, component (A) includes the case of a GTL-based wax isomerization lubricating base oil manufactured by a method to isomerize GTL WAX (gas-to-liquid wax) manufactured by a
10 process such as a Fischer-Tropsch process, and the like. The method of manufacturing the wax isomerization lubricating base oil in this case has the same basic manufacturing process as the manufacturing process for hydrocracked base oil.

[0022] The total aromatic content in the mineral lubricating base oil in
15 component (A) is not particularly limited, yet the total aromatic content is 3% by mass or less in one embodiment, 1% by mass or less in another embodiment, and 0.5% by mass or less in yet another embodiment. As the total aromatic content in the mineral lubricating base oil is smaller, i.e. as aromaticity is lower, the problem of solubility of sludge occurs more easily.
20 Note that the above total aromatic content denotes the aromatic fraction content measured in conformity with ASTM D2549.

[0023] The sulfur content of the mineral lubricating base oil that is component (A) is 0.03% by mass or less. In one embodiment, the sulfur content is 0.01% by mass or less, and in another embodiment, the mineral
25 lubricating base oil substantially does not include sulfur. A lower sulfur content means a higher degree of refinement, making the problem of solubility of sludge occur more easily.

[0024] The kinematic viscosity at 100°C of the mineral lubricating base oil that is component (A) is 3 mm²/s to 35 mm²/s, preferably 4 mm²/s or more,
30 and particularly preferably 5 mm²/s or more, and is preferably 34 mm²/s or less, and particularly preferably 33 mm²/s or less. When the kinematic viscosity at 100°C of the mineral lubricating base oil of component (A) exceeds 35 mm²/s, the low temperature viscosity characteristics worsen, whereas when the kinematic viscosity is less than 3 mm²/s, oil film formation

is insufficient at the lubrication spot, causing lubricity to deteriorate and loss of lubricating base oil by evaporation to increase. Note that in the present invention, the kinematic viscosity at 100°C refers to the kinematic viscosity at 100°C as prescribed by ASTM D-445.

5 [0025] The viscosity index of the mineral lubricating base oil that is component (A) is 80 or more. The viscosity index is 95 or more in one embodiment and is 105 or more in another embodiment. As the viscosity index of the mineral lubricating base oil is higher, the problem of solubility of sludge occurs more easily. Note that in the present invention, the viscosity
10 index denotes the viscosity index measured in conformity with JIS K2283-2000.

[0026] On the other hand, no particular restriction is placed on the upper limit of the viscosity index of the mineral lubricating base oil that is component (A), and a base oil with a viscosity index of approximately 125 to
15 170 may be used, such as normal paraffin, slack wax, GTL wax, or the like, or an isoparaffinic mineral oil in which these are isomerized. With respect to low-temperature fluidity, however, the viscosity index of the mineral lubricating base oil is preferably 160 or less.

[0027] The content of the mineral lubricating base oil that is component
20 (A) is preferably 50% by mass or more in terms of total content of the base oil, more preferably 55% by mass or more, and even more preferably 60% by mass or more. Furthermore, the content is preferably 95% by mass or less and more preferably 90% by mass or less.

[0028] The base oil in the lubricating oil composition for trunk piston
25 diesel engines according to the present invention includes, as component (B), 5% by mass or more, in terms of total content of the base oil, of an extract (B1) yielded as a by-product during solvent refining in a mineral lubricating base oil manufacturing process, or 20% by mass or more, in terms of total content of the base oil, of a mineral lubricating base oil (B2) with a saturated
30 hydrocarbon content of less than 90% by mass, a sulfur content exceeding 0.03% by mass in terms of element content, and a kinematic viscosity at 100°C of 30 mm²/s or more.

[0029] The extract yielded as a by-product during solvent refining contains 70% to 99% aromatic compounds by column chromatography,

includes 15% or more of aromatic hydrocarbon compounds (%C_A) according to a composition analysis method stipulated in ASTM D2140, and includes 5% to 25% by mass of Polycyclic Aromatic (PCA) compounds extracted by dimethyl sulfoxide (DMSO) according to the IP 346 method prescribed by the
5 Institute of Petroleum.

[0030] The method of manufacturing the extract yielded as a by-product during solvent refining is not particularly limited, yet one example thereof is to use oil obtained as follows: the lubricating oil fraction and reduced-pressure distillation residual oil obtained by reduced-pressure
10 distillation of crude oil are subjected to deasphalting and subsequently to dewaxing and hydrotreating as necessary, and then the oil is subjected to a solvent extraction process with a solvent having affinity for aromatic hydrocarbons.

[0031] The above solvent extraction process refers to an operation using a solvent to separate the oil into a raffinate with little aromatic content and an
15 extract with a high aromatic content. As the solvent, furfural, phenol, cresol, sulfolane, N-methylpyrrolidone, dimethyl sulfoxide, formylmorpholine, a glycol-based solvent, or the like is used.

[0032] In recent years, however, importance has been placed on the carcinogenicity of Polycyclic Aromatic (PCA) compounds. In Europe, an indication of toxicity is required for oils and the like that include 3% by mass or more of PCA, and action is being taken to restrict their usage. Accordingly, the extract (B1) that is component (B) preferably has a PCA content of less
20 than 3% by mass, i.e. the Polycyclic Aromatic (PCA) compound content extracted by dimethyl sulfoxide (DMSO) according to the IP 346 method prescribed by the Institute of Petroleum is preferably less than 3% by mass.

[0033] The content of PCA in the extract varies according to the separation capacity during the solvent extraction process, the solvent that is used, the stock oil / solvent ratio, the reaction temperature, and the like.
30 Accordingly, by appropriately changing these conditions, the PCA content can be controlled to be 3% by mass or less. Furthermore, in order to control the PCA content of the extract (B1) to be 3% by mass or less, a hydrocracking process is preferably used.

[0034] The method of manufacturing the extract (B1) as component (B)

with a PCA content of less than 3% by mass is not limited, yet the following method of manufacturing is provided as an example.

[0035] JP H6-505524 A discloses a process to manufacture process oil with the PCA content reduced to less than 3% by mass by subjecting
5 reduced-pressure distillation residue to deasphalting and dewaxing the resulting oil. JP H7-501346 A discloses a non-carcinogenic bright stock extract as well as a deasphalted oil with a low PCA content and a production process thereof, and discloses an oil obtained by deasphalting residue in a vacuum distillation column, an oil with reduced aromatic compounds via an
10 extraction process on deasphalted oil, and an oil obtained by the deasphalting process.

[0036] JP H11-80751 A discloses a method of manufacturing that, by solvent extraction, uses a countercurrent extraction column to perform extraction under specific conditions to obtain, from a mineral-based
15 hydrocarbon mixture, an extracted oil with a polycyclic aromatic compound content of less than 1.6% by mass by the IP 346 test method, and then by second-stage solvent extraction, obtains a mineral-based aromatic hydrocarbon oil, as an extracted oil, with a polycyclic aromatic compound content of less than 3% by mass by the IP 346 test method.

20 [0037] Furthermore, JP 2000-80208 A discloses a method of manufacturing rubber process oil including a raw material adjustment step to adjust stock oil selected from the group consisting of lubricating oil fraction by reduced-pressure distillation of crude oil and deasphalted oil by deasphalting reduced-pressure distillation residue of crude oil, and a solvent
25 extraction step to perform solvent extraction on the stock oil with a solvent having selective affinity for aromatic hydrocarbons, wherein extraction conditions are set so that the polycyclic aromatic compound content of the extract determined in accordance with the IP 346 method is less than 3% by mass, and the aniline point is 80°C or less.

30 [0038] The extract (B1) that is component (B) preferably has low carcinogenicity due to PCA, as described above, and preferably has a mutagenicity index MI of less than 1.0. Of course, the extract more preferably has PCA of less than 3% by mass and a mutagenicity index MI of less than 1.0. The extract even more preferably has PCA of less than 3% by mass and a

mutagenicity index MI of less than 0.4.

[0039] The mutagenicity index MI is the mutagenicity index MI as stipulated in conformity with the "Standard Test Method for Determining Carcinogenic Potential of Virgin Base Oils in Metalworking Fluids",
5 stipulated in ASTM-E-1687-10.

[0040] The method of manufacturing the extract (B1) that is component (B) with a mutagenicity index MI of less than 1.0 is not particularly limited, yet as an example, process oil is disclosed in JP 3624646 B2.

[0041] Furthermore, the extract (B1) that is component (B) preferably has
10 a benzo[a]pyrene (BaP) content of 1 mg/kg or less and a particular aromatic compound (PAH) content of 10 mg/kg or less, since at these values, there is no risk of carcinogenicity. Here, a particular aromatic compound (PAH) denotes the aromatic compounds (PAH) 1) to 8) below.

- 1) Benzo[a]pyrene (BaP)
- 15 2) Benzo[e]pyrene (BeP)
- 3) Benzo[a]anthracene (BaA)
- 4) Chrysene (CHR)
- 5) Benzo[b]fluoranthene (BbFA)
- 6) Benzo[j]fluoranthene (BjFA)
- 20 7) Benzo[k]fluoranthene (BkFA)
- 8) Dibenzo[a,h]anthracene (DBAhA)

Note that quantitative analysis by GC-MS analysis can be performed for these particular aromatic compounds on test material prepared by separating and concentrating the target component and then adding an internal standard
25 material.

[0042] The method of manufacturing the extract for which the benzo[a]pyrene (BaP) content is 1 mg/kg or less and the particular aromatic compound (PAH) content is 10 mg/kg or less is not limited. For example, JP 2010-229314 A discloses a method of manufacturing an extract for which
30 the %C_A by ASTM D3238 is 25 to 45, the benzo[a]pyrene (BaP) content is 1 mg/kg or less, and the particular aromatic compound (PAH) content is 10 mg/kg or less.

[0043] The extract (B1) that is component (B) preferably has a bay proton concentration (%H_{Bay}) of less than 0.35%. Here, bay protons refer to the ratio

of hydrogen atoms in a portion called the "Bay region", surrounded by condensed benzene rings, as measured by ^1H -NMR. The bay proton concentration is used to judge the carcinogenicity due to the structure of an aromatic compound. The measurement method is ISO 21461,

5 "Rubber-Determination of the aromaticity of oil in vulcanized rubber compound". It is said that carcinogenicity is higher as the bay proton concentration is higher, and a bay proton concentration of less than 0.35% is preferable.

[0044] The extract (B1) that is component (B) particularly preferably has a
10 benzo[a]pyrene (BaP) content of 1 mg/kg or less, a particular aromatic compound (PAH) content of 10 mg/kg or less, a bay proton concentration ($\%H_{\text{Bay}}$) of less than 0.35%, and a mutagenicity index MI of less than 1.0.

[0045] In the present invention, the extract (B1) that is component (B) preferably has a kinematic viscosity at 100°C of 5 mm²/s to 100 mm²/s. If the
15 kinematic viscosity at 100°C exceeds 100 mm²/s, workability decreases. On the other hand, if the kinematic viscosity at 100°C is less than 5 mm²/s, it becomes extremely difficult to ensure sufficient aromaticity, which may prevent the effects of the present invention from being achieved. Furthermore, the kinematic viscosity at 100°C is preferably 50 mm²/s or less and preferably
20 20 mm²/s or more. If the kinematic viscosity at 100°C is 50 mm²/s or less, the high temperature detergency is high. The high temperature detergency is also high if the kinematic viscosity at 100°C is 20 mm²/s or more.

[0046] When the $\%C_A$ (ASTM D2140) of the extract (B1) that is component (B) is less than 15%, the solubility might not be sufficient. On the
25 other hand, a $\%C_A$ (ASTM D2140) of the extract that exceeds 50% is not preferable, since it becomes extremely difficult to set the DMSO extractable portion to less than 3%, thus worsening the economic efficiency of the manufacturing process.

[0047] The extract (B1) that is component (B) preferably has an aniline
30 point of 90°C or less. An aniline point of the extract that exceeds 90°C is not preferable, since the solubility decreases.

[0048] If the aromatic content by column chromatography of the extract (B1) that is component (B) is less than 60%, the solubility may decrease. On the other hand, an aromatic content by column chromatography of the extract

that exceeds 95% is not preferable, since it becomes extremely difficult to set the DMSO extractable portion to less than 3%, worsening the economic efficiency of the manufacturing process.

[0049] When the lubricating oil composition according to the present invention includes the extract (B1) as component (B), the content of the extract (B1) is 5% by mass or more, preferably 10% by mass or more, in terms of total content of the base oil. The content of the extract is preferably 90% by mass or less and more preferably 80% by mass or less in terms of total content of the base oil. If the content of the extract that is component (B) is less than 5% by mass, the piston detergency worsens, whereas upon exceeding 90% by mass, the viscosity index decreases, yielding a larger increase in viscosity at low temperatures. Therefore, contents of less than 5% by mass and more than 90% by mass are not preferable.

[0050] On the other hand, as component (B), the lubricating oil composition according to the present invention may include 20% by mass or more, in terms of total content of the base oil, of a mineral lubricating base oil (B2) with a saturated hydrocarbon content of less than 90% by mass, a sulfur content exceeding 0.03% by mass in terms of element content, and a kinematic viscosity at 100°C of 30 mm²/s or more.

[0051] The mineral lubricating base oil (B2) that is component (B) has a saturated hydrocarbon content of less than 90% by mass, a sulfur content exceeding 0.03% by mass in terms of element content, and a kinematic viscosity at 100°C of 30 mm²/s or more and is classified in group I in accordance with base oil classification by the American Petroleum Institute (API).

[0052] The method of manufacturing the mineral lubricating base oil (B2) is not particularly limited, yet typically, the base oil is manufactured by subjecting the atmospheric distillation residue, yielded by subjecting crude oil to atmospheric distillation, to further reduced-pressure distillation, then bringing out the necessary viscosity fraction and refining the result.

[0053] The total aromatic content of the mineral lubricating base oil (B2) is not particularly limited yet is preferably 30% by mass or more, more preferably 35% by mass or more, and particularly preferably 40% to 60% by mass. Note that the total aromatic content denotes the aromatic fraction

content measured in conformity with ASTM D2549.

[0054] The sulfur content of the mineral lubricating base oil (B2) exceeds 0.03% by mass, is 0.1% by mass or more in one embodiment, and is 0.2% to 1% by mass in another embodiment.

5 [0055] The kinematic viscosity at 100°C of the mineral lubricating base oil (B2) is 30 mm²/s or more, preferably 30 mm²/s to 40 mm²/s, and particularly preferably 30 mm²/s to 35 mm²/s. If the kinematic viscosity at 100°C of the mineral lubricating base oil (B2) is less than 30 mm²/s, the solubility of sludge decreases.

10 [0056] When the lubricating oil composition according to the present invention includes the mineral lubricating base oil (B2) as component (B), the content of the mineral lubricating base oil (B2) is 20% by mass or more, preferably 25% by mass or more, more preferably 30% by mass or more, preferably 50% by mass or less, and more preferably 45% by mass or less in
15 terms of total content of the base oil.

[0057] When the base oil in the lubricating oil composition for trunk piston diesel engines according to the present invention includes, as component (B), 5% by mass or more, in terms of total content of the base oil, of the above-described extract (B1), the base oil preferably further includes
20 (C) a polybutene-based synthetic oil or a hydride thereof. The polybutene-based synthetic oil or a hydride thereof is particularly preferably polybutene. Polybutene is a polymer of butene, which is an olefin having a carbon number of 4.

[0058] The polybutene-based synthetic oil or hydride thereof that is
25 component (C) normally refers to a copolymeric substance, or the hydrogenated and saturated double bond of a copolymeric substance, obtained by cationic polymerization, using a catalyst such as aluminum chloride or the like, of the remnant after extracting butadiene from the C₄ fraction generated when producing ethylene or propylene by cracking naphtha, i.e. the
30 butane-butene fraction. Here, the term "butane-butene fraction" includes isobutane, n-butane, isobutylene, 1-butene, trans-2-butene, cis-2-butene, and the like.

[0059] The kinematic viscosity at 100°C of the polybutene-based synthetic oil or hydride thereof is preferably 60 mm²/s or more and more preferably 100

mm²/s or more, and is preferably 350 mm²/s or less and more preferably 250 mm²/s or less. When the kinematic viscosity at 100°C of the polybutene-based synthetic oil or hydride thereof is 60 mm²/s or more, the viscosity of the base oil rises sufficiently, thus achieving sufficient engine lubricity. When the
5 kinematic viscosity is 250 mm²/s or less, the piston detergency is good, and the increase in the amount of exhaust-related carbon sediment can be suppressed.

[0060] The polybutene-based synthetic oil or hydride thereof preferably has a number average molecular weight of 500 or more and less than 1500.
10 The number average molecular weight is more preferably 500 to 1000 and even more preferably 500 to 900. When the number average molecular weight of the polybutene-based synthetic oil or hydride thereof is 500 or more, the viscosity of the base oil rises sufficiently, thus achieving sufficient engine lubricity. When the number average molecular weight is less than 1500, the
15 piston detergency is good, and the increase in the amount of exhaust-related carbon sediment can be suppressed.

[0061] When the lubricating oil composition according to the present invention includes the polybutene-based synthetic oil or hydride thereof in component (C), the content thereof is preferably 5% to 60% by mass, more
20 preferably 50% by mass or less, even more preferably 40% by mass or less, and most preferably 30% by mass or less in terms of total content of the base oil. If the content of component (C) is 5% by mass or more, viscosity as lubricating oil can be sufficiently ensured, and if the content is 60% by mass or less, lubrication problems due to an excessively high viscosity can be
25 prevented.

[0062] A synthetic oil-based base oil that does not fall under the component (C) may be mixed into the base oil of the lubricating oil composition according to the present invention. Specifically, examples of such a synthetic oil-based base oil include an oligomer of isobutene, or a
30 poly- α -olefin, or hydride thereof, that is an oligomer of an α -olefin with a carbon number of 8 to 14, representative examples of which include a homooligomer and/or a co-oligomer of 1-octene, 1-decene, and 1-dodecene; diesters such as ditridecyl glutarate, di-2-ethyl hexyl adipate, diisodecyl adipate, ditridecyl adipate, and di-2-ethyl hexyl sebacate; polyol esters such

as trimethylol propane caprylate, trimethylol propane pelargonate, pentaerythritol-2-ethyl hexanoate, and pentaerythritol pelargonate; copolymers of a dicarboxylic acid such as dibutyl maleate and an α -olefin with a carbon number of 2 to 30; aromatic synthetic oils such as alkyl naphthalene, alkyl benzene, and aromatic esters, or mixtures thereof; and the like. Among these, a preferable synthetic oil-based base oil is an oligomer of an α -olefin with a carbon number of 8 to 14, called a poly- α -olefin (PAO).

[0063] The base oil in the lubricating oil composition according to the present invention has a kinematic viscosity at 100°C in a range of 5 mm²/s to 16 mm²/s, preferably 6 mm²/s or more, more preferably 7 mm²/s or more, preferably 15 mm²/s or less, and more preferably 14 mm²/s or less. If the kinematic viscosity at 100°C of the base oil is less than 5 mm²/s, there is a risk of lubricity deteriorating since the oil film formation is insufficient at the lubrication spot, and of an increase in the loss of base oil by evaporation. If the kinematic viscosity at 100°C of the base oil exceeds 12 mm²/s, there is a risk of a problem occurring in fluidity at low temperatures.

[0064] The base oil of the lubricating oil composition according to the present invention preferably has a viscosity index of 85 or more and more preferably 90 or more. If the viscosity index of the base oil is 85 or more, the oil film maintenance at high temperatures and the viscosity resistance inhibition at low temperatures are good.

[0065] In the lubricating oil composition according to the present invention, the bicyclic or higher aromatic content, by alumina silica chromatographic analysis, included in the base oil is preferably 2% by mass or more and more preferably in a range of 3% to 20% by mass. If the bicyclic or higher aromatic content included in the base oil is 2% by mass or more, the high temperature detergency of the lubricating oil composition is particularly good.

[0066] The amount of loss by evaporation of the base oil of the lubricating oil composition according to the present invention is preferably a NOACK evaporation amount of 20% by mass or less, more preferably 16% by mass or less, and particularly preferably 10% by mass or less. A NOACK evaporation amount of the base oil that exceeds 20% by mass is not preferable, since the evaporation loss of the lubricating oil composition grows large, causing an

increase in viscosity and the like. The NOACK evaporation loss referred to here is a measurement of the evaporation loss of base oil measured in conformity with ASTM D5800.

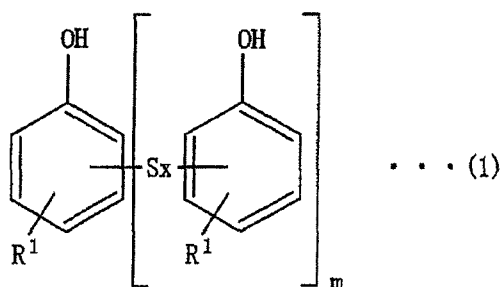
[0067] The lubricating oil composition for trunk piston diesel engines according to the present invention includes (D) a metallic detergent (also referred to below as component (D)) as an essential component.

[0068] Any compound normally used in lubricating oil can be used as the metallic detergent of the component (D). Examples include sulfonate detergents, phenate detergents, salicylate detergents, naphthenate detergents, and the like. A single type of the above metallic detergents may be used, or two or more types may be used in combination.

[0069] Examples of a sulfonate detergent that can be used include an alkali metal salt, alkaline earth metal salt, or (overbased) basic salt of alkyl aromatic sulfonic acid obtained by sulfonation of an alkyl aromatic compound with a weight-average molecular weight of 400 to 1500, preferably 700 to 1300. Examples of the alkali metal or alkaline earth metal include sodium, potassium, magnesium, barium, and calcium. Magnesium and calcium are preferable, with calcium being particularly preferable. Examples of the alkyl aromatic sulfonic acid include so-called petroleum sulfonic acid and synthetic sulfonic acid. Examples of the petroleum sulfonic acid referred to here generally include the result of sulfonating an alkyl aromatic compound of lubricating oil distillate in mineral oil, as well as so-called mahogany acid, which is a by-product when manufacturing white oil. The synthetic sulfonic acid may, for example, be the result of sulfonating an alkyl benzene having a straight-chain or branched alkyl group obtained as a by-product from a plant for producing alkyl benzene used as the raw material for a detergent or obtained by an alkylation of a polyolefin in benzene. The result of sulfonating an alkyl naphthalene, such as dinonylnaphthalene, may also be used. The sulfonating agent when sulfonating these alkyl aromatic compounds is not particularly limited, yet typically fuming sulfuric acid or sulfuric anhydride is used.

[0070] As the above phenate detergent, an alkylphenol sulfide alkali metal salt, alkaline earth metal salt, or (overbased) basic salt having the structure shown in the following formula (1) may be used. Examples of the alkali metal

or alkaline earth metal include sodium, potassium, magnesium, barium, and calcium. Magnesium and calcium are preferable, with calcium being particularly preferable.



5

[0071] In the formula (1), R^1 represents a straight-chain or branched, saturated or unsaturated alkyl group or alkenyl group with a carbon number of 6 to 21, m represents the degree of polymerization and is an integer from 1 to 10, S represents elemental sulfur, and x represents an integer from 1 to 3.

[0072] The carbon number of the alkyl group or alkenyl group in the formula (1) is preferably from 9 to 18 and more preferably from 9 to 15. When the carbon number is less than 6, the solubility in the base oil may decrease, whereas when the carbon number exceeds 21, production becomes difficult, and heat resistance may worsen.

[0073] The phenate metal detergent preferably includes an alkylphenol sulfide metal salt for which the degree of polymerization m in the formula (1) is 4 or more, particularly 4 to 5, since the resulting heat resistance is excellent.

[0074] Examples of the above salicylate detergent include an alkali metal, alkaline earth metal salicylate, or (overbased) basic salt thereof having one hydrocarbon group with a carbon number of 1 to 19; an alkali metal, alkaline earth metal salicylate, or (overbased) basic salt thereof having one hydrocarbon group with a carbon number of 20 to 40; and an alkali metal, alkaline earth metal salicylate, or (overbased) basic salt thereof having two or more hydrocarbon groups with a carbon number of 1 to 40. These hydrocarbon groups may be the same or different. Among these, use of an alkali metal, alkaline earth metal salicylate, or (overbased) basic salt thereof having one hydrocarbon group with a carbon number of 8 to 19 is preferable, since

20
25

low-temperature fluidity is excellent. Examples of the alkali metal or alkaline earth metal include sodium, potassium, magnesium, barium, and calcium. Magnesium and/or calcium are preferable, with use of calcium being particularly preferable.

5 [0075] The base number of the component (D) is preferably in a range from 50 mg KOH/g to 500 mg KOH/g, with a range from 100 mg KOH/g to 450 mg KOH/g being more preferable, and a range from 120 mg KOH/g to 400 mg KOH/g being even more preferable. When the base number is less than 50 mg KOH/g, corrosion and wear may greatly increase, whereas when exceeding
10 500 mg KOH/g, problems may occur with solubility.

[0076] The metal ratio of the component (D) is not particularly limited, yet it is preferable to use a component (D) having a metal ratio with a lower limit preferably of 1 or more, more preferably 2 or more, and even more preferably 2.5 or more, and an upper limit of preferably 20 or less, more
15 preferably 19 or less, and even more preferably 18 or less. Note that the metal ratio referred to here is expressed as the valence of the metal element $\times$ the content of the metal element (mol %)/soap group content (mol %) in the component (D). Furthermore, the metal element refers to calcium, magnesium, or the like, and the soap group refers to a sulfonic acid group, phenol group,
20 salicylic acid group, or the like.

[0077] In the lubricating oil composition according to the present invention, a single component (D) may be used, yet two or more types are preferably used in combination. When used in combination, one of the following combinations is particularly preferable: (1) overbased Ca phenate /
25 overbased Ca sulfonate, (2) overbased Ca phenate / overbased Ca salicylate, and (3) overbased Ca phenate / overbased Ca sulfonate / overbased Ca salicylate.

[0078] The preferable ratio for (1) overbased Ca phenate / overbased Ca sulfonate and (2) overbased Ca phenate / overbased Ca salicylate is 0.1 or
30 more as a weight ratio of the additive blend, with 0.2 or more being more preferable and 0.3 or more being most preferable. The reason is that when the ratio is less than 0.1, heat resistance worsens. A ratio of 9 or less is preferable, with 7 or less being more preferable, and 5 or less being most preferable. The reason is that if the ratio exceeds 9, the height in the TGA burning test is

insufficient, and the deposits on the piston top land are not sufficiently reduced.

[0079] In the case of (3) overbased Ca phenate / overbased Ca sulfonate / overbased Ca salicylate, the ratio of the sum of overbased Ca sulfonate and overbased Ca salicylate to overbased Ca phenate is preferably the above-indicated ratio. In this case, the weight ratio of the content of overbased Ca sulfonate / overbased Ca salicylate is not limited, yet a value of 0.1 or more is preferable, with 0.2 or more being more preferable, and 0.3 or more being most preferable. The reason is that if the weight ratio is less than 0.1, deposits may end up increasing in conditions greatly exceeding 300°C. A weight ratio of 9 or less is preferable, with 7 or less being more preferable, and 5 or less being most preferable. A weight ratio exceeding 9 causes the detergency to decrease.

[0080] The content by percentage of the component (D) in the lubricating oil composition according to the present invention is, in terms of total content of the composition, preferably 3% to 30% by mass, more preferably 6% to 25% by mass, and even more preferably 8% to 20% by mass. When the content by percentage of the component (D) is less than 3% by mass, the necessary detergency and acid neutralization characteristics might not be obtained, whereas when exceeding 30% by mass, an excessive metallic component may form a deposit on the piston.

[0081] The metal element content based on the component (D) in the lubricating oil composition according to the present invention is, in terms of total content of the composition, preferably 0.35% to 3.6% by mass, more preferably 1.0% to 2.9% by mass, and particularly preferably 1.4% to 2.7% by mass. When the metal element content based on the component (D) is less than 0.7% by mass, the necessary detergency and acid neutralization characteristics might not be obtained, whereas when exceeding 3.6% by mass, excessive ash may form a deposit on the piston top land, which may lead to scuffing or bore polishing of the liner.

[0082] The lubricating oil composition for trunk piston diesel engines according to the present invention includes (E) an ashless dispersant (also referred to below as component (E)) as an essential component.

[0083] Any ashless dispersant used in lubricating oil may be used as the

component (E). Examples include a nitrogen-containing compound or a derivative thereof having in the molecule at least one straight-chain or branched alkyl group or alkenyl group with a carbon number of 40 to 400, preferably 60 to 350, a Mannich base dispersant, or a denatured alkenyl succinimide. Any single type, or two or more types, selected from the above
5 may be blended and used.

[0084] When the carbon number of the alkyl group or alkenyl group in the nitrogen-containing compound or derivative thereof is less than 40, the solubility in the lubricant base oil may decrease, whereas when the carbon
10 number exceeds 400, the low-temperature fluidity of the lubricating oil composition according to the present invention may worsen. The alkyl group or alkenyl group may be straight-chain or branched, and preferable examples include a branched alkyl group or branched alkenyl group derived from olefin oligomers such as propylene, 1-butene, isobutylene, and the like, or from a
15 co-oligomer of ethylene and propylene.

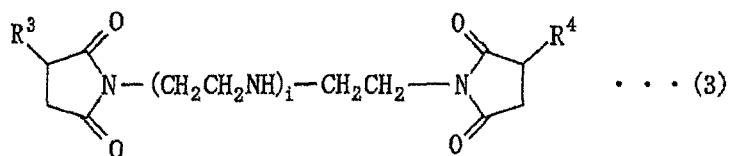
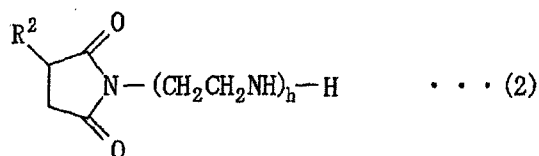
[0085] Examples of the component (E) include a single type, or two or more types, selected from among components (E-1) through (E-3) below.

(E-1): succinimide, or a derivative thereof, containing at least one alkyl group or alkenyl group with a carbon number of 40 to 400 in the molecule;

20 (E-2): benzylamine, or a derivative thereof, containing at least one alkyl group or alkenyl group with a carbon number of 40 to 400 in the molecule;
and

(E-3): polyamine, or a derivative thereof, containing at least one alkyl group or alkenyl group with a carbon number of 40 to 400 in the molecule.

25 [0086] Examples of component (E-1) above include the compounds shown in the following formulas (2) and (3).



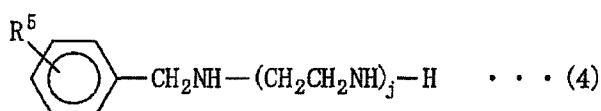
[0087] In the formula (2), R² represents an alkyl group or alkenyl group with a carbon number of 40 to 400, preferably 60 to 350, and h represents an integer from 1 to 5, preferably from 2 to 4.

[0088] In the formula (3), R³ and R⁴ independently represent an alkyl group or alkenyl group with a carbon number of 40 to 400, preferably 60 to 350, and more preferably represent a polybutenyl group. Furthermore, i represents an integer from 0 to 4, preferably from 1 to 3.

[0089] Component (E-1) includes a so-called monotype succinimide represented by the formula (2), in which succinic anhydride is attached to one end of a polyamine, and a so-called bis-type succinimide represented by the formula (3), in which succinic anhydride is attached to both ends of a polyamine. Either, or a mixture of both, may be included in the composition according to the present invention.

[0090] The method of manufacturing the succinimide in component (E-1) is not particularly limited. For example, the succinimide may be obtained by reacting a compound having an alkyl group or alkenyl group with a carbon number of 40 to 400 with maleic anhydride at 100°C to 200°C, and reacting the resulting alkyl succinic acid or alkenyl succinic acid with polyamine. Examples of polyamine include diethylenetriamine, triethylenetetramine, tetraethylenepentamine, and pentaethylenhexamine.

[0091] Examples of component (E-2) above include the compound shown in the following formula (4).



[0092] In the formula (4), R^5 represents an alkyl group or alkenyl group with a carbon number of 40 to 400, preferably 60 to 350, and j represents an integer from 1 to 5, preferably from 2 to 4.

[0093] The method of manufacturing the benzylamine in component (E-2) is not particularly limited. Examples include a method to react a polyolefin, such as a propylene oligomer, polybutene, or ethylene- α -olefin copolymer, with a phenol to yield alkyl phenol, and then to react the alkyl phenol with formaldehyde and with a polyamine such as diethylenetriamine, triethylenetetramine, tetraethylenepentamine, or pentaethylenehexamine via a Mannich reaction.

[0094] Examples of component (E-3) above include the compound shown in the following formula (5).



[0095] In the formula (5), R^6 represents an alkyl group or alkenyl group with a carbon number of 40 to 400, preferably 60 to 350, and k represents an integer from 1 to 5, preferably from 2 to 4.

[0096] The method of manufacturing the polyamine in component (E-3) is not particularly limited. Examples include a method to chlorinate a polyolefin, such as a propylene oligomer, polybutene, or ethylene- α -olefin copolymer and then to react the result with ammonia and a polyamine such as ethylenediamine, diethylenetriamine, triethylenetetramine, tetraethylenepentamine, or pentaethylenehexamine.

[0097] Examples of the derivative of a nitrogen-containing compound listed as an example of the component (E) include a so-called denatured compound from an oxygen-containing organic compound, in which a monocarboxylic acid, such as a fatty acid, with a carbon number of 1 to 30, or a polycarboxylic acid, such as oxalic acid, phthalic acid, trimellitic acid, or pyromellitic acid, with a carbon number of 2 to 30, or anhydride of these acids, or an ester compound, an alkylene oxide with a carbon number of 2 to 6, or hydroxy(poly)oxyalkylene carbonate is caused to act on the above-described

nitrogen-containing compound, and a portion or the entirety of the remaining amino group and/or imino group is neutralized or amidated; a so-called boron denatured compound in which boric acid is caused to act on the above-described nitrogen-containing compound, and a portion or the entirety of the remaining amino group and/or imino group is neutralized or amidated; a so-called phosphoric acid denatured compound in which phosphoric acid is caused to act on the above-described nitrogen-containing compound, and a portion or the entirety of the remaining amino group and/or imino group is neutralized or amidated; a sulfur denatured compound in which a sulfur compound is caused to act on the above-described nitrogen-containing compound; and a denatured compound in which the above-described nitrogen-containing compound is combined with two or more denatured components selected from among a denatured oxygen-containing organic compound, denatured boron, denatured phosphoric acid, and denatured sulfur. Among these derivatives, a boric acid denatured compound of alkenyl succinimide, in particular a boric acid denatured compound of a bis-type alkenyl succinimide, can further enhance heat resistance by being used along with the above-described component (A).

[0098] The content by percentage of the component (E) in the lubricating oil composition according to the present invention is, in terms of total content of the composition, preferably 0.1% to 3.0% by mass, more preferably 0.2% to 2.5% by mass, and even more preferably 0.3% to 2.0% by mass. The content by percentage of the component (E) is, as nitrogen content in terms of total content of the composition, normally 0.005% to 0.4% by mass, preferably 0.01% to 0.2% by mass, more preferably 0.01% to 0.1% by mass, and even more preferably 0.02% to 0.05% by mass. Furthermore, when using a boron-containing ashless dispersant as the component (E), the mass ratio of the boron content to the nitrogen content (B/N ratio) is not particularly limited yet is preferably from 0.5 to 1 and more preferably from 0.7 to 0.9. A higher B/N ratio makes it easier to enhance the wear resistance and anti-scuffing performance, yet a ratio exceeding 1 leads to concerns about safety. When using a boron-containing ashless dispersant, the content by percentage is not particularly limited, yet the boron content in terms of total content of the composition is preferably from 0.001% to 0.1% by mass, more preferably

from 0.005% to 0.05% by mass, and even more preferably from 0.01% to 0.04% by mass.

[0099] The component (E) in the lubricating oil composition of the present invention is preferably a boron-containing ashless dispersant with a boron
5 content of at least 0.5% by mass, more preferably at least 1.0% by mass, even more preferably at least 1.5% by mass, and still more preferably 1.8% by mass. In particular, a bis-type boron-containing succinimide-based ashless dispersant is most preferably included. Note that the boron-containing ashless dispersant with a boron content of at least 0.5% by mass as described herein
10 may include a diluent oil, such as a mineral oil or a synthetic oil, accounting for 10% to 90% by mass, preferably 30% to 70% by mass, and the boron content normally refers to the boron content in a state including the diluent oil.

[0100] The number average molecular weight (M_n) of the ashless
15 dispersant of component (E) in the lubricating oil composition according to the present invention is preferably 2500 or more, more preferably 3000 or more, even more preferably 4000 or more, and most preferably 5000 or more. Furthermore, the number average molecular weight (M_n) is preferably 10000 or less. If the number average molecular weight of the ashless dispersant is
20 less than 2500, dispersibility may be insufficient. Conversely, if the number average molecular weight of the ashless dispersant exceeds 10000, viscosity is too high, making fluidity insufficient and leading to an increase in deposits.

[0101] In the present invention, the content and effective concentration of the ashless dispersant of component (E) are preferably such that the product of
25 the number average molecular weight (M_n), the content, and the effective concentration of the ashless dispersant is 9000 or more. The effective concentration of the ashless dispersant of component (E) (the ratio of the mass remaining in the rubber membrane to the amount of the initially collected sample) is preferably in a range from 0.30 to 0.70, and the concentration in
30 the composition of the ashless dispersant of component (E) (the product of the content and the effective concentration) is preferably in a range from 0.9% to 14% by mass in terms of total content of the lubricating oil composition.

[0102] The lubricating oil composition according to the present invention preferably includes a sulfur-based extreme pressure agent as an additional

component. Preferable examples of the sulfur-based extreme pressure agent include dihydrocarbyl polysulfide, sulfurized fatty acid, sulfurized olefin, sulfurized ester, sulfurized fat, sulfurized mineral oil, a thiazole compound, a thiadiazole compound, and an alkyl thiocarbamate compound.

5 [0103] The lubricating oil composition according to the present invention preferably includes an organic molybdenum compound. Examples of the organic molybdenum compound include an organic molybdenum compound that includes sulfur, such as molybdenum dithiophosphate and molybdenum dithiocarbamate (MoDTC); a complex of a molybdenum compound (for
10 example, molybdenum oxide such as molybdenum dioxide or molybdenum trioxide; a molybdic acid such as orthomolybdic acid, paramolybdic acid, and sulfurized (poly)molybdic acid; a metal salt of these molybdic acids, or a molybdic acid salt such as an ammonium salt of these molybdic acids; molybdenum sulfide such as molybdenum disulfide, molybdenum trisulfide,
15 molybdenum pentasulfide, or molybdenum polysulfide; sulfurized molybdenum acid, metal or amine salt of sulfurized molybdenum acid, or halogenated molybdenum such as molybdenum chloride) and a sulfur-containing organic compound (for example, alkyl(thio)xanthate, thiaziazole, mercaptothiadiazole, thiocarbonate, tetrahydrocarbyl thiuram
20 disulfide, bis(di(thio)hydrocarbyl dithiophosphonate)disulfide, organic (poly) sulfide, and sulfurized ester) or other organic compound; or a complex of a sulfur-containing molybdenum compound, such as the above molybdenum sulfide and sulfurized molybdenum acid, and alkenyl succinimide.

[0104] Furthermore, as an antiwear agent, the lubricating oil composition
25 according to the present invention preferably includes a zinc dithiophosphate (ZnDTP). Examples of the zinc dithiophosphate include zinc dialkyldithiophosphate that includes a straight-chain or branched (primary, secondary, or tertiary, with primary or secondary being preferable) alkyl
30 group with a carbon number of 3 to 18, preferably 3 to 10, such as dipropyl zinc dithiophosphate, dibutyl zinc dithiophosphate, dipentyl zinc dithiophosphate, dihexyl zinc dithiophosphate, diheptyl zinc dithiophosphate, or dioctyl zinc dithiophosphate; and di((alkyl)aryl)zinc dithiophosphate having an aryl group or alkylaryl group with a carbon number of 6 to 18, preferably 6 to 10, such as diphenyl zinc dithiophosphate or ditolyl zinc

dithiophosphate, or a mixture of two or more of these.

[0105] In addition to the above structural components, in order to further improve the properties of the lubricating oil composition of the present invention or to add other required properties, the lubricating oil composition
5 may accordingly further include any additives that are typically used in a lubricating oil. Examples of such additives include antioxidants, ashless friction modifiers, corrosion inhibitors, rust inhibitors, demulsifiers, metal deactivators, anti-foaming agents, and dyes.

[0106] Examples of the antioxidant include phenol-based or amine-based
10 ashless antioxidants; and metallic antioxidants such as zinc-based, copper-based, and molybdenum-based antioxidants. When included, the content of the antioxidant in terms of total content of the composition is normally 0.1% to 5% by mass.

[0107] Examples of the ashless friction modifier include fatty acid esters,
15 aliphatic amines, and fatty acid amides. When included, the content of the friction modifier in terms of total content of the composition is normally 0.1% to 5% by mass.

[0108] Examples of the corrosion inhibitor include benzotriazole-based, tolyltriazole-based, thiadiazole-based, and imidazole-based compounds.

20 [0109] Examples of the rust inhibitor include petroleum sulfonates, alkyl benzene sulfonates, dinonylnaphthalene sulfonates, alkenyl succinic acid esters, and polyhydric alcohol esters.

[0110] Examples of the demulsifier include polyalkylene glycol-based non-ionic surfactants such as polyoxyethylene alkyl ethers, polyoxyethylene
25 alkyl phenyl ethers, and polyoxyethylene alkyl naphthyl ethers.

[0111] Examples of the metal deactivator include imidazolines, pyrimidine derivatives, alkyl thiadiazoles, mercaptobenzothiazoles, benzotriazoles and derivatives thereof, 1,3,4-thiadiazole polysulfide, 1,3,4-thiadiazolyl-2,5-bisdialkyl dithiocarbamate, 2-(alkyldithio)
30 benzoimidazole, and β -(o-carboxybenzylthio) propionitrile.

[0112] Examples of the anti-foaming agent include silicone oil, alkenylsuccinic acid derivatives, and the like with a kinematic viscosity at 25°C of 0.1 mm²/s to less than 100 mm²/s.

[0113] When these additives are included in the lubricating oil

composition according to the present invention, the content in terms of total content of the composition is normally selected from a range of 0.005% to 5% by mass, and the anti-foaming agent is normally selected from a range of 0.0005% to 1% by mass.

5 [0114] The lubricating oil composition for trunk piston diesel engines according to the present invention preferably has a kinematic viscosity at 100°C of 5.6 mm²/s to 16.3 mm²/s and more preferably 7 mm²/s to 15 mm²/s. If the kinematic viscosity at 100°C of the lubricating oil composition is 5.6 mm²/s or more, the oil film forming ability is sufficient, and the occurrence of
10 scuffing or the occurrence of excessive wear can be suppressed. Furthermore, if the kinematic viscosity is 16.3 mm²/s or less, sufficient lubricating performance that exhibits good spread through the piston liner can be maintained.

[0115] In the lubricating oil composition for trunk piston diesel engines
15 according to the present invention, the base number is preferably 9 mg KOH/g to 55 mg KOH/g (perchloric acid method), more preferably 10 mg KOH/g to 50 mg KOH/g, and even more preferably 11 mg KOH/g to 45 mg KOH/g. If the base number of the lubricating oil composition is less than 9 mg KOH/g, acid neutralization characteristics are insufficient, and piston detergency is
20 insufficient. Furthermore, a base number of the lubricating oil composition that exceeds 55 mg KOH/g yields an excessive base number, i.e. metal carbonate forms deposits, leading to wear and to the piston ring sticking. In the present invention, the base number denotes the base number measured by a perchloric acid method in conformity with section 7 of JIS K2501, "Petroleum
25 products and lubricants - Determination of neutralization number".

EXAMPLES

[0116] The present invention will be described in more detail with reference to the following Examples and Comparative Examples, yet the present invention is not limited thereto.

30 [0117] (Examples 1 to 10, Comparative Examples 1 to 4)

Lubricating oil compositions with the formulations shown in Table 1 were prepared, and a hot tube test was performed in conformity with JPI-5S-55-99. Table 1 lists the results. Note that in Table 1, the amount of the base oil is the content in terms of total content of the base oil, whereas the

amount of the additives is the content in terms of total content of the composition.

[0118] <Hot tube test>

- Using mixed oils with 90% by mass of each test oil and 10% by mass of
- 5 C heavy oil, a hot tube test was performed at 300°C in conformity with JPI-5S-55-99, and assessment was performed by rating the depth of hue of the discolored portion in the test tube after the test (from 0 points (black) to 10 points (transparent = best)). A higher rating indicates better high temperature detergency.

[0119] [Table 1]

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Comp. Ex. 1	Comp. Ex. 2	Ex. 7	Ex. 8	Ex. 9	Ex. 10	Comp. Ex. 3	Comp. Ex. 4
		29	41	35	55	53	60	15	30	8	16	12	19	78	5
Base oil	Mineral base oil 1 % by mass	60	39	55	25	17		85	60	64	51	68	53	22	82
	Mineral base oil 2 % by mass									18	13				
	Mineral base oil 3 % by mass														
	Mineral base oil 4 % by mass					30	40		10						
Kinematic viscosity at 100°C of base oil	Polybutene % by mass									10	20	10	8		13
	Extract 1 % by mass	11	20							10			20		
	Extract 2 % by mass			10	20										
	Kinematic viscosity at 100°C of base oil mm ² /s	9.6	9.6	9.6	9.6	9.6	9.9	9.6	9.4	13.1	13.0	13.2	13.5	13.1	14.5
Aromatic content in base oil	Total aromatic % by mass	9.5	17.3	8.8	17.6	16.0	21.3	0.0	5.3	8.6	17.3	8.6	17.3	0.0	0.0
	Monocyclic aromatic % by mass	4.0	7.3	2.8	5.6	12.0	16.0	0.0	4.0	3.7	7.3	3.7	7.3	0.0	0.0
	Bicyclic aromatic % by mass	3.4	6.3	3.6	7.1	3.2	4.3	0.0	1.1	3.1	6.3	3.1	6.3	0.0	0.0
	Tricyclic or higher aromatic % by mass	2.0	3.7	2.4	4.9	0.8	1.0	0.0	0.3	1.8	3.7	1.8	3.7	0.0	0.0
Additive	Bicyclic or higher aromatic % by mass	5.5	10.0	6.0	12.0	4.0	5.3	0.0	1.3	5.0	10.0	5.0	10.0	0.0	0.0
	(D) Ca salicylate % by mass	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
	(D) Ca phenate % by mass	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	(E) Dispersant % by mass	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Kinematic viscosity at 100°C of composition	(F) Antioxidant % by mass	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	0.5
	Kinematic viscosity at 100°C of composition mm ² /s	11.0	11.0	11.1	11.0	11.0	11.3	11.0	10.8	14.5	14.4	14.6	14.9	14.5	6.0
	Base number of composition (perchloric acid method) mg KOH/g	30.1	30.3	30.0	30.1	30.1	30.0	30.1	30.2	30.1	30.2	30.1	30.0	30.3	30.1
	Hot tube test assessment (300°C)	3.5	4.5	3.5	5.0	3.0	3.5	2.0/2.5	2.0	3.0	4.5	4.0	5.0	2.0	2.5

[0120] Mineral base oil 1: group II base oil, kinematic viscosity at 40°C = 31.0 mm²/s, kinematic viscosity at 100°C = 5.6 mm²/s, viscosity index = 119, %C_A = 0, %C_N = 27.1, %C_P = 72.9, nitrogen content = less than 3 ppm, sulfur content = 0.01% by mass, saturated hydrocarbon content = 98.8% by mass

Mineral base oil 2: group II base oil, kinematic viscosity at 40°C = 93.9 mm²/s, kinematic viscosity at 100°C = 10.7 mm²/s, viscosity index = 97, %C_A = 0, %C_N = 33.9, %C_P = 66.1, nitrogen content = less than 3 ppm, sulfur content = 0.01% by mass, saturated hydrocarbon content = 98.9% by mass

Mineral base oil 3: group II base oil, kinematic viscosity at 40°C = 387.3 mm²/s, kinematic viscosity at 100°C = 29.4 mm²/s, viscosity index = 105, %C_A = 0, %C_N = 28.8, %C_P = 71.2, nitrogen content = less than 100 ppm, sulfur content = 4 mass ppm, saturated hydrocarbon content = 99.1% by mass

Mineral base oil 4: group I base oil, kinematic viscosity at 40°C = 476.1 mm²/s, kinematic viscosity at 100°C = 31.4 mm²/s, viscosity index = 96, %C_A = 8, %C_N = 23.3, %C_P = 68.6, nitrogen content = 54 ppm, sulfur content = 0.44% by mass, saturated hydrocarbon content = 47.1% by mass

[0121] Polybutene, kinematic viscosity at 40°C = 3450 mm²/s, kinematic viscosity at 100°C = 110 mm²/s, viscosity index = 98, number average molecular weight = 800

[0122] Extract 1: TDAE, kinematic viscosity at 40°C = 1185 mm²/s, kinematic viscosity at 100°C = 34.1 mm²/s, viscosity index = 14, %C_A = 29.5, %C_N = 16.3, %C_P = 54.2, nitrogen content = 870 ppm, sulfur content = 3.8% by mass, DMSO extraction PCA amount = 2.8% by mass

Extract 2: RAE, kinematic viscosity at 40°C = 3739 mm²/s, kinematic viscosity at 100°C = 70.5 mm²/s, viscosity index = 36, %C_A = 33.8, %C_N = 7.2, %C_P = 59.0, nitrogen content = 1500 ppm, sulfur content = 3.7% by mass, benzo[a]pyrene content = less than 0.5 mg/kg, 8 types of PAH (*(1) benzo[a]anthracene, (2) benzo[b]fluoranthene, (3) benzo[j]fluoranthene, (4) benzo[k]fluoranthene, (5) benzo[a]pyrene, (6) dibenzo[a,h]anthracene, (7) triphenylene, (8) chrysene)) = less than 1.6 mg/kg, MI value = less than 0.4

[0123] Ca salicylate: 230 mg KOH/g

Ca phenate: 250 mg KOH/g

Dispersant: boronated alkenylsuccinimide, boron content = 0.5% by

mass

Antioxidant: zinc-based antioxidant

[0124] The results for Examples 1 to 4 and Comparative Example 1 show that as compared to the test oil formed from a group II type mineral base oil
5 (Comparative Example 1), the test oils that further combined an extract and added aromatic content (Examples 1 to 4) exhibited excellent high temperature detergency.

[0125] The results for Examples 5 and 6 and Comparative Example 2 show that blending 20% by mass or more, in terms of total content of the base oil, of
10 a group I type mineral base oil into a group II type mineral base oil leads to expression of excellent high temperature detergency.

[0126] Furthermore, the results for Examples 7 to 10 show that combining an extract into a group II type mineral base oil and further combining polybutene improves the high temperature detergency of the composition.

15 [0127] The above results show that by combining an extract or a group I type mineral base oil into a group II and/or group III type mineral base oil, it is possible to provide a lubricating oil composition for trunk piston diesel engines that has a proper amount of aromatic component content and excellent high temperature detergency, while maintaining an appropriate viscosity.

20

CLAIMS

[Claim 1]

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

5 a base oil with a kinematic viscosity at 100°C of 5 mm²/s to 16 mm²/s including:

(A) 50% by mass or more, in terms of total content of the base oil, of a mineral lubricating base oil with a saturated hydrocarbon content of 90% by mass or more, a sulfur content of 0.03% by mass or less in terms of element content, a viscosity index of 80 or more, and a kinematic viscosity at 100°C of 3 mm²/s to 35 mm²/s; and

10 (B) 20% by mass to 50% by mass, in terms of total content of the base oil, of a mineral lubricating base oil (B2) with a saturated hydrocarbon content of less than 90% by mass, a sulfur content exceeding 0.03% by mass in terms of element content, and a kinematic viscosity at 100°C of 30 mm²/s or more,

the base oil being compounded with:

15 (D) a metallic detergent; and

(E) an ashless dispersant.

[Claim 2]

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

20 a base oil with a kinematic viscosity at 100°C of 5 mm²/s to 16 mm²/s including:

(A) a mineral lubricating base oil with a saturated hydrocarbon content of 90% by mass or more, a sulfur content of 0.03% by mass or less in terms of element content, a viscosity index of 80 or more, and a kinematic viscosity at 100°C of 3 mm²/s to 35 mm²/s, wherein the mineral lubricating base oil is 50% by mass or more of a total
25 content of the base oil;

(B) 5% by mass to 90% by mass, in terms of total content of the base oil, of an extract (B1) yielded as a by-product during solvent refining in a mineral lubricating base oil manufacturing process, the extract (B1) containing 15% to 50% of aromatic hydrocarbon compounds (%C_A) according to a composition analysis method
30 stipulated in ASTM D2140, wherein the extract (B1) is 5% by mass to 20% by mass of the total content of the base oil; and

(C) a polybutene-based synthetic oil or a hydride thereof with a

kinematic viscosity at 100°C of 60 mm²/s or more, wherein the polybutene-based synthetic oil or the hydride thereof is 5% by mass to 40% by mass of the total content of the base oil,

the base oil being compounded with:

5 (D) a metallic detergent; and

(E) an ashless dispersant.

[Claim 3]

10 The lubricating oil composition for a trunk piston diesel engine according to claim 2, wherein component (B) is an extract with a PCA content of less than 3% by mass.

[Claim 4]

15 The lubricating oil composition for a trunk piston diesel engine according to claim 2 or 3, wherein component (B) is an extract with an MI value of less than 1.0, a benzo[a]pyrene content of 1 mg/kg or less, and a particular aromatic compound (PAH) content of 10 mg/kg or less.

[Claim 5]

20 The lubricating oil composition for a trunk piston diesel engine according to any one of claims 1 to 4, wherein a bicyclic or higher aromatic content included in the base oil is 2% by mass or more.

[Claim 6]

25 The lubricating oil composition for a trunk piston diesel engine according to any one of claims 1 to 5, wherein kinematic viscosity at 100°C is 5.6 mm²/s to 16.3 mm²/s, and a base number is 9 mg KOH/g to 55 mg KOH/g (perchloric acid method).