



(11) **EP 2 905 323 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.08.2015 Bulletin 2015/33

(51) Int Cl.:
C10M 169/04 (2006.01)

(21) Application number: **15153425.2**

(22) Date of filing: **02.02.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **31.01.2014 JP 2014016942**

(71) Applicants:
• **IDEMITSU KOSAN CO., LTD.**
Tokyo 100-8321 (JP)
• **TOYOTA JIDOSHA KABUSHIKI KAISHA**
Toyota-shi, Aichi-ken, 471-8571 (JP)

(72) Inventors:
• **Ito, Koki**
Chiba, 299-0107 (JP)
• **Fujimoto, Kosuke**
Aichi, 471-8571 (JP)
• **Yamashita, Minoru**
Aichi, 471-8571 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) **Lubricating oil composition**

(57) [Problem]

To provide a lubricating oil composition capable of attaining high-level fuel efficiency, durability and piston detergency in internal-combustion engines.

[Means for Resolution]

The lubricating oil composition according to the present invention contains a viscosity index improver and a metallic detergent in at least one base oil selected from mineral oils and synthetic oils therein, wherein the viscosity index improver contains a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver, the polymethacrylate viscosity index improver is contained in an amount of from 3.0% by mass to 9.5% by mass based on the total amount of the lubri-

cating oil composition, the metallic detergent is at least one selected from calcium sulfonate, calcium phenate and calcium salicylate, the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition, the high-temperature high-shear viscosity at 150°C of the lubricating oil composition is 2.6 mPa·s or more, the high-temperature high-shear viscosity at 80°C of the lubricating oil composition is 7.8 mPa·s or less, and the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less.

EP 2 905 323 A1

Description

Technical Field

5 **[0001]** The present invention relates to a lubricating oil composition for use in internal-combustion engines such as diesel engines, gasoline engines, gas engines, engines for hybrid cars, etc.

Background Art

10 **[0002]** At present, with the surge of the consciousness for the environment on the earth scale, implementation of measures against environmental issues such as global warming, etc., as well as against depletion of oil resources is desired. In vehicle-related fields, emission control, development of fuel-efficient automobiles and others are much more desired.

15 **[0003]** For measures for emission control, employed are exhaust gas filters such as diesel particulate filters, gasoline particulate filters and the like for removing metal fractions (also referred to as ash fractions) derived from lubricating oil compositions used in internal-combustion engines, and exhaust-gas aftertreatment devices such as ternary catalysts, oxidation catalysts, etc.

20 **[0004]** In this case, it is known that metal fractions mix in exhaust gas streams and deposit in aftertreatment devices to lower the removal efficiency. Accordingly, it is proposed to reduce the content of a metallic additive, especially a metallic detergent, which is contained in a lubricating oil composition for internal-combustion engines (see Patent Literature 1).

[0005] In addition, for measures for fuel efficiency improvement, it is now under way to control the kinematic viscosity of lubricating oil compositions for use in internal-combustion engines while maintaining the balance thereof with wear amount reduction.

25 **[0006]** In particular, HTHS viscosity indicates a lowered viscosity in high-temperature high-shear conditions, and means an effective viscosity on a high-temperature and high-speed slide face. In internal-combustion engines, a lower HTHS viscosity improves fuel efficiency. However, a too low HTHS viscosity increases a wear amount. Given the situation, it is proposed to control the kinematic viscosity in a temperature range having some influence on fuel consumption while maintaining the balance thereof with resistance to abrasion (see Patent Literature 2).

30

Citation List

Patent Literature

35 **[0007]**

[Patent Literature 1] Japanese Patent 4965228

[Patent Literature 2] JP-A-2010-280821

40 Summary of Invention

Technical Problem

45 **[0008]** As in Patent Literature 1, reduction in metallic additives such as a metallic detergent, an anti-wear agent and the like results in significant deterioration of durability and piston detergency that are important functions of lubricating oil compositions. Further, deterioration of characteristics of lubricating oil compositions may lower fuel efficiency.

[0009] Against deterioration of piston detergency, it may be taken into consideration to add an antioxidant or incorporate an ash-free dispersant. However, an ash-free dispersant increases the viscosity of lubricating oil compositions, and is therefore often useless from the viewpoint of fuel efficiency improvement.

50 **[0010]** As in the above, there is much room for further improvement to satisfy the requirements of fuel efficiency, durability and piston detergency in internal-combustion engines that are required in late years.

[0011] Given the situation, an object of the present invention is to provide a lubricating oil composition capable of attaining fuel efficiency, durability and piston detergency in internal-combustion engines at a high-level.

55 Solution to Problem

[0012] The present inventors have made assiduous studies and, as a result, have found that a lubricating oil composition containing a base oil, a viscosity index improver and a metallic detergent, which is so controlled that the ratio of the high-

temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof could be a specific value by the use of a specific viscosity index improver therein, can solve the above-mentioned problems, and have completed the present invention. Specifically, the present invention provides the following:

- [1] A lubricating oil composition comprising a viscosity index improver and a metallic detergent in at least one base oil selected from mineral oils and synthetic oils therein, wherein the viscosity index improver contains a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver, the polymethacrylate viscosity index improver is contained in an amount of from 3.0% by mass to 9.5% by mass based on the total amount of the lubricating oil composition, the metallic detergent contains at least one selected from calcium sulfonate, calcium phenate and calcium salicylate, the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition, the high-temperature high-shear viscosity at 150°C of the lubricating oil composition is 2.6 mPa·s or more, the high-temperature high-shear viscosity at 80°C of the lubricating oil composition is 7.8 mPa·s or less, and the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less;
- [2] The lubricating oil composition according to the above [1], wherein the NOACK value, as measured in the NOACK test at 250°C for 1 hour according to ASTM D 5800, is 13% by mass or less;
- [3] The lubricating oil composition according to the above [1] and [2], wherein the polymethacrylate viscosity index improver is a non-dispersant type polymethacrylate viscosity index improver;
- [4] The lubricating oil composition according to any of the above [1] to [3], wherein the content of the olefin copolymer viscosity index improver is from 30 parts by mass to 250 parts by mass relative to 100 parts by mass of the polymethacrylate viscosity index improver;
- [5] The lubricating oil composition according to any of the above [1] to [4], wherein the weight-average molecular weight of the polymethacrylate viscosity index improver is from 100,000 to 500,000;
- [6] The lubricating oil composition according to any of the above [1] to [5], which contains an antioxidant selected from a phenol-based antioxidant and an amine-based antioxidant in an amount of from 0.5% by mass to 10% by mass based on the total amount of the lubricating oil composition;
- [7] A method for producing a lubricating oil composition, which comprises:

incorporating a viscosity index improver that contains a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver so that the amount of the polymethacrylate viscosity index improver is from 3.0% by mass to 9.5% by mass based on the total amount of the lubricating oil composition, and a metallic detergent containing at least one selected from calcium sulfonate, calcium phenate and calcium salicylate, in at least one base oil selected from mineral oils and synthetic oils:

so that the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition, that the high-temperature high-shear viscosity at 150°C of the lubricating oil composition is 2.6 mPa·s or more, that the high-temperature high-shear viscosity at 80°C of the lubricating oil composition is 7.8 mPa·s or less, and that the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less.

Advantageous Effects of Invention

[0013] According to the present invention, there can be provided a lubricating oil composition capable of attaining fuel efficiency, durability and piston detergency in internal-combustion engines at a high level.

Description of Embodiments

[Lubricating Oil Composition]

[0014] The lubricating oil composition of the present invention is a lubricating oil composition containing a viscosity index improver and a metallic detergent in at least one base oil selected from mineral oils and synthetic oils therein, wherein the viscosity index improver contains a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver, the metallic detergent contains at least one selected from calcium sulfonate, calcium phenate and calcium salicylate, the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition, the high-temperature high-shear viscosity at 150°C of the lubricating

oil composition is 2.6 mPa·s or more, the high-temperature high-shear viscosity at 80°C of the lubricating oil composition is 7.8 mPa·s or less, and the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less.

<Base Oil>

[0015] The base oil to be applied to the lubricating oil composition of this embodiment is at least one selected from mineral oils and synthetic oils, for which any arbitrary one may be suitably selected from mineral oils and synthetic oils used as a base oil in lubricating oil compositions.

[0016] As the mineral oils, for example, there are mentioned mineral oils prepared by purifying a lubricating oil fraction obtained through reduced-pressure distillation of an atmospheric residue to be obtained in atmospheric distillation of a crude oil, through one or more treatments of solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, catalytic dewaxing, hydrorefining, etc., or mineral oils produced through isomerization of wax or GTL wax, etc.

[0017] As the synthetic oils, for example, there are mentioned polybutenes, polyolefins [α -olefin homopolymers and copolymers (for example, ethylene- α -olefin copolymers), etc.], various esters (for example, polyol esters, dibasic acid esters, phosphoric acid esters, etc.), various ethers (for example, polyphenyl ethers, etc.), polyglycols, alkylbenzene, alkylnaphthalenes, etc. Of those synthetic oils, especially preferred are polyolefins or polyol esters, from the viewpoint of the high-temperature high-shear viscosity characteristics thereof and the solubility therein of additives such as viscosity index improvers, etc.

[0018] In this embodiment, one alone or two or more different types of the above-mentioned mineral oils may be used either singly or as combined. Also, one alone or two or more different types of the above-mentioned synthetic oils may be used either singly or as combined. Further, one or more mineral oils and one or more synthetic oils may be combined. In particular, in the lubricating oil composition of the present invention, preferred is combined use of a paraffin mineral oil and a poly- α -olefin, from the viewpoint that the NOACK value of the lubricating oil composition, as measured in the NOACK test at 250°C for 1 hour according to ASTM D 5800, can be readily made to be 13% by mass or less.

[0019] The viscosity of the base oil may be selected in accordance with the intended use of the lubricating oil composition, the product grade, etc. The kinematic viscosity at 100°C of the base oil may be from 2 mm²/s to 30 mm²/s, and is preferably from 2 mm²/s to 15 mm²/s. More preferably, the kinematic viscosity is from 2 mm²/s to 10 mm²/s.

[0020] When the kinematic viscosity at 100°C is 2 mm²/s or more, then the value loss could be small; and when it is 30 mm²/s or less, then the power loss owing to viscosity resistance could be inhibited and a fuel efficiency improving effect may be realized.

[0021] In the base oil, the paraffin fraction (this may be expressed as % C_P) in ring analysis is 70% or more. When % C_P is less than 70%, then the oxidation stability is poor so that the acid value may increase or sludge may form. From these viewpoints, % C_P is preferably 80% or more.

[0022] Further, the viscosity index of the base oil is 100 or more, preferably 110 or more, more preferably 120 or more. The base oil having a viscosity index of less than 120 could experience a significant viscosity change with changes in temperature, therefore detracting from fuel efficiency improvement at low temperatures.

<Viscosity Index Improver>

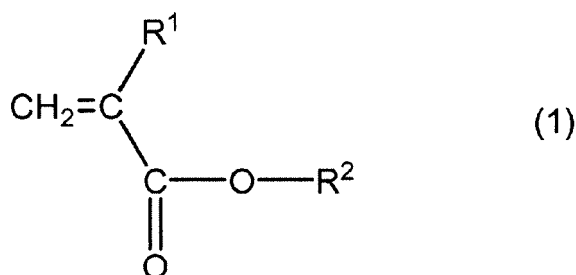
[0023] The viscosity index improver applicable to the lubricating oil composition of this embodiment includes a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver.

(Polymethacrylate Viscosity Index Improver)

[0024] As the polymethacrylate viscosity index improver, usable here is a non-dispersant type polymethacrylate viscosity index improver. In the lubricating oil composition of the present invention, preferably used is a non-dispersant type polymethacrylate viscosity index improver, since the amount of a deposit which adheres to pistons may be lowered even under high-temperature high-shear conditions and therefore piston detergency may be high.

[0025] On the other hand, a dispersant type polymethacrylate viscosity index improver is a copolymer produced through addition copolymerization with a nitrogen-containing group as a polar monomer in the molecule, and may therefore adhere to pistons and others via the polar group to increase the amount of adhering deposits under high-temperature high-shear conditions.

[0026] The polymethacrylate viscosity index improver to be used in the lubricating oil composition of this embodiment includes a non-dispersant type poly(meth)acrylate compound to be produced through homopolymerization of one monomer represented by a general formula (1) or copolymerization of two or more of the monomers represented by a general formula (1).



In the above general formula (1), R¹ represents a hydrogen atom or a methyl group, R² represents a linear or branched hydrocarbon group having from 1 to 200 carbon atoms.

[0027] The lubricating oil composition of this embodiment of the present invention contains a polymethacrylate viscosity index improver in an amount of from 3.0% by mass to 9.5% by mass based on the total amount of the lubricating oil composition.

[0028] When the content of the polymethacrylate viscosity index improver is less than 3.0% by mass based on the total amount of the lubricating oil composition, then the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof could not be made to be 2.05 or less.

[0029] On the other hand, when the content of the polymethacrylate viscosity index improver is more than 9.5% by mass, then piston deposits may form and the durability and the piston detergency may lower.

[0030] From the viewpoint of easiness in readily making the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition of this embodiment to the high-temperature high-shear viscosity at 150°C thereof 2.05 or less and in readily improving fuel efficiency, the content of the polymethacrylate viscosity index improver is preferably 4.0% by mass or more, more preferably 6.0% by mass or more.

[0031] From the viewpoint of easiness in improving the durability and the piston detergency, the content of the polymethacrylate viscosity index improver is preferably 9.0% by mass or less, more preferably 8.0% by mass or less.

[0032] The polymethacrylate viscosity index improver for use in the present invention preferably has a weight-average molecular weight of from 100,000 to 500,000, more preferably from 250,000 to 500,000.

[0033] Using such a polymethacrylate viscosity index improver that has a weight-average molecular weight falling within the above range, it is easy to provide the lubricating oil composition in which the high-temperature high-shear viscosity at 150°C is 2.6 mPa·s or more, the high-temperature high-shear viscosity at 80°C is 7.8 mPa·s or less, and the ratio of the high-temperature high-shear viscosity at 100°C to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less.

(Olefin Copolymer Viscosity Index Improver)

[0034] As the olefin copolymer viscosity index improver usable in this embodiment, there are mentioned a styrene-diene hydrogenated copolymer, an ethylene- α -olefin copolymer or its hydrogenated derivative, a polyisobutylene or its hydrogenated derivative, and a polyalkylstyrene or their mixture, etc.

[0035] The styrene-diene hydrogenated copolymer is a compound produced by hydrogenating a copolymer of styrene and a diene. The diene usable here concretely includes butadiene, isoprene, etc. Especially preferred is a hydrogenated copolymer of styrene and isoprene.

[0036] The ethylene- α -olefin copolymer or its hydrogenated derivative is a copolymer of ethylene and an α -olefin or a compound produced by hydrogenating the copolymer. As the α -olefin, concretely, propylene, isobutylene, 1-butene, 1-pentene, 1-hexene, 1-octene, 1-decene, 1-dodecene, etc. may be used.

[0037] The weight-average molecular weight of the olefin copolymer viscosity index improver is preferably 10,000 or more, more preferably 20,000 or more, even more preferably 50,000 or more, and is preferably, 800,000 or less, more preferably 600,000 or less, even more preferably 500,000 or less.

[0038] The olefin copolymer viscosity index improver having a weight-average molecular weight of from 10,000 to 800,000 can realize a sufficient viscosity index improving effect and can be effective for improving fuel efficiency.

[0039] In this embodiment, both a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver are used as combined.

[0040] The polymethacrylate viscosity index improver contributes toward lowering the HTHS viscosity at 80°C to 100°C of the composition. However, the polymethacrylate viscosity index improver tends to lower the piston detergency. Consequently, for example, in internal-combustion engines such as diesel engines that are required to realize high-level piston detergency, a polymethacrylate viscosity index improver has not been used heretofore.

[0041] As opposed to this, in this embodiment, a polymethacrylate viscosity index improver is positively combined

with an olefin copolymer viscosity index improver to realize the lubricating oil composition being excellent in durability without detracting from the piston detergency thereof.

[0042] Preferably in the lubricating oil composition of the present invention, the content of the olefin copolymer viscosity index improver is from 30 parts by mass to 250 parts by mass relative to 100 parts by mass of the polymethacrylate viscosity index improver, more preferably from 40 parts by mass to 200 parts by mass, even more preferably from 45 parts by mass to 150 parts by mass. Controlling the content of the olefin copolymer viscosity index improver to fall with the above range makes it possible to reduce the necessary amount of the metallic detergent not increasing the ash-free dispersant such as succinimide or the like, and therefore realizes excellent durability and improved piston detergency.

[0043] When the content of the olefin copolymer viscosity index improver is from 2% by mass to 12.0% by mass based on the total amount of the lubricating oil composition, then a sufficient viscosity index improving effect may be realized.

[0044] When a styrene-diene hydrogenated copolymer, an ethylene- α -olefin copolymer, a hydrogenated derivative of an ethylene- α -olefin copolymer, a polyisobutylene, a hydrogenated derivative of a polyisobutylene, a polyalkylstyrene or a mixture thereof is used as the olefin copolymer viscosity index improver, the preferred quantity ranges as recited above, e.g. from 30 parts by mass to 250 parts by mass relative to 100 parts by mass of the polymethacrylate viscosity index improver, or from 2% by mass to 12.0% by mass based on the total amount of the lubricating oil composition, pertain to these specific olefin copolymer viscosity index improvers individually or in combination.

<Metallic Detergent>

[0045] The lubricating oil composition of the present invention contains a metallic detergent, the metallic detergent contains at least one selected from calcium sulfonate, calcium phenate and calcium salicylate, and the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition of the present invention.

[0046] In case where already-existing lubricating oil compositions contain a calcium detergent as a metallic detergent for realizing sufficient durability and piston detergency, the calcium content therein must be at least 2000 ppm. However, with emission control being strengthened year by year, it has become necessary to remove more ash fractions through exhaust gas filters or in gas aftertreatment devices, and therefore in the case of using already-existing lubricating oil compositions, the amount of ash fractions depositing on exhaust gas filters or in gas aftertreatment devices may increase.

[0047] As opposed to this, the lubricating oil composition of the present invention contains, as mentioned above, a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver such that the high-temperature high-shear viscosity at 150°C of the lubricating oil composition is 2.6 mPa·s or more, that the high-temperature high-shear viscosity at 80°C of the lubricating oil composition is 7.8 mPa·s or less, and that the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less, in which the content of the polymethacrylate viscosity index improver is from 3.0% by mass to 9.5% by mass based on the total amount of the lubricating oil composition, and consequently, even though the metallic detergent in the composition is so reduced that the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition, the composition can still maintain or even improve the detergency not requiring increase in the amount of the ash-free dispersant therein.

[0048] In the lubricating oil composition of the present invention, the calcium amount is 1500 ppm or less, and therefore the ash fractions that may deposit on exhaust gas filters or in gas after treatment devices can be reduced. Further, metal surface abrasion by calcium can be inhibited.

[0049] The lubricating oil composition of the present invention exhibits excellent durability and piston detergency even though the calcium content therein is 500 ppm. However, calcium may improve durability and piston detergency, and therefore, the calcium content in the lubricating oil composition of the present invention is preferably from 700 ppm to 1400 ppm based on the total amount of the lubricating oil composition, more preferably from 1000 ppm to 1400 ppm.

[0050] As the calcium sulfonate for use in the lubricating oil composition of the present invention, there is mentioned a calcium salt of an alkyl-aromatic sulfonic acid to be produced by sulfonating an alkyl-aromatic compound having a molecular weight of from 300 to 1,500, preferably from 400 to 700.

[0051] As the calcium phenate, there are mentioned calcium salts of an alkylphenol, an alkylphenol sulfide, and a Mannich reaction product of an alkylphenol.

[0052] As the calcium salicylate, there is mentioned a calcium salt of an alkylsalicylic acid.

[0053] The alkyl group for constituting the calcium detergent is preferably an alkyl group having from 4 to 30 carbon atoms, more preferably having from 6 to 18 carbon atoms, and the group may be linear or branched. The group may be a primary alkyl group, a secondary alkyl group or a tertiary alkyl group.

[0054] Alkaline earth metal sulfonates, alkaline earth metal phenates and alkaline earth metal salicylates include neutral alkaline earth metal sulfonates, neutral alkaline earth metal phenates and neutral alkaline earth metal salicylates to be produced by directly reacting the above-mentioned alkyl-aromatic sulfonic acid, alkylphenol, alkylphenol sulfide, Mannich reaction product of alkyl phenol, alkylsalicylic acid or the like with an alkaline earth metal base such as an

oxide, a hydroxide or the like of at least one alkaline earth metal selected from magnesium and calcium.

[0055] Calcium sulfonate, calcium phenate and calcium salicylate include neutral calcium sulfonate, neutral calcium phenate and neutral calcium salicylate to be produced by once forming the above-mentioned alkyl-aromatic sulfonic acid, alkylphenol, alkylphenol sulfide, Mannich reaction product of alkyl phenol, alkylsalicylic acid or the like into an alkali metal salt such as a sodium salt, potassium salt or the like thereof followed by substituting the alkali metal of the resultant salt with calcium.

[0056] Further, calcium sulfonate, calcium phenate and calcium salicylate include basic calcium metal sulfonate, basic calcium phenate and basic calcium salicylate to be produced by heating neutral calcium sulfonate, neutral calcium phenate and neutral calcium salicylate along with an excessive calcium salt or calcium base in the presence of water.

[0057] Further, calcium sulfonate, calcium phenate and calcium salicylate include overbased calcium sulfonate, overbased calcium phenate and overbased calcium salicylate to be produced by reacting neutral calcium sulfonate, neutral calcium phenate and neutral calcium salicylate with a calcium carbonate or borate in the presence of carbonic dioxide.

[0058] As calcium sulfonate, calcium phenate and calcium salicylate, usable here are the above-mentioned neutral salt, basic salt, overbased salt and their mixture, etc. In particular, from the viewpoint of calcium reduction, preferred is use of one or more of overbased salicylate, overbased phenate and overbased sulfonate. For realizing excellent durability and piston detergency as well as abrasion resistance, more preferred is combined use of one or more of overbased salicylate, overbased phenate and overbased sulfonate, and neutral sulfonate.

[0059] The calcium detergent is sold on the market generally in the form thereof diluted with a light lubricant base oil or the like, and is commercially available. The calcium detergent preferred for use herein is one having a calcium content of from 1.0% by mass to 20% by mass, more preferably from 2.0% by mass to 16% by mass.

[0060] The base value of the calcium detergent is preferably from 10 mg KOH/g to 600 mg KOH/g, more preferably from 20 mg KOH/g to 500 mg KOH/g. The total base value as referred to herein means the total base value in the potentiometric titration method (base value/perchloric acid method) according to JIS K2501 "7. Test Method for Neutralization Titer for Petroleum Products and Lubricating Oils".

[0061] The metal ratio with respect to the calcium detergent is not specifically defined. In general, one alone or two or more different metallic detergents having a metal ratio of 20 or less may be used here either singly or as combined. Preferably, as the essential ingredient thereof, a metallic detergent having a metal ratio of 3 or less, more preferably 1.5 or less, even more preferably 1.2 or less, can be used, because of excellence in oxidation stability, base value retentivity, high-temperature detergency, and the like. The metal ratio as referred to herein is represented by (number of calcium element valences) x (calcium content, mol%)/(soap group content, mol%) in the calcium detergent, in which the soap group means a sulfonic acid group, a phenol group, a salicylic acid group, or the like, with respect to the calcium detergent.

[0062] The lubricating oil composition of the present invention may contain any other metallic detergent in addition to the above-mentioned at least one selected from calcium sulfonate, calcium phenate and calcium salicylate, within a range not detracting from the advantageous effects of the present invention.

[0063] For example, there are mentioned metallic detergents containing one or more compounds selected from alkali metal sulfonates, alkali metal phenates, alkali metal salicylates, alkaline earth metal sulfonates, alkaline earth metal phenates and alkaline earth metal salicylates. Preferred is at least any one of alkyl metal sulfonates and alkaline earth metal sulfonates. The alkali metal is preferably sodium, and the alkaline earth metal is preferably magnesium.

<Additives>

[0064] If desired and within a range not detracting from the advantageous effects of the present invention, any other additives such as antioxidant, metallic detergent, viscosity index improver, pour-point depressant, rust inhibitor, metal inactivator, defoaming agent, anti-wear agent, extreme-pressure agent and the like may be added to the lubricating oil composition of the present invention.

(Antioxidant)

[0065] As antioxidant, usable here is one selected from a phenol-based antioxidant and an amine-based antioxidant.

[0066] The phenol-based antioxidant includes, for example, octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate; 4,4'-methylenebis(2,6-di-t-butylphenol); 4,4'-bis(2,6-di-t-butylphenol); 4,4'-bis(2-methyl-6-t-butylphenol); 2,2'-methylenebis(4-ethyl-6-t-butylphenol); 2,2'-methylenebis(4-methyl-6-t-butylphenol); 4,4'-butylidenebis(3-methyl-6-t-butylphenol); 4,4'-isopropylidenebis(2,6-di-t-butylphenol); 2,2'-methylenebis(4-methyl-6-nonylphenol); 2,2'-isobutylidenebis(4,6-dimethylphenol); 2,2'-methylenebis(4-methyl-6-cyclohexylphenol); 2,6-di-t-butyl-4-methylphenol; 2,6-di-t-butyl-4-ethylphenol; 2,4-dimethyl-6-t-butylphenol; 2,6-di-t-amyl-p-cresol; 2,6-di-t-butyl-4-(N,N'-dimethylaminomethylphenol); 4,4'-thiobis(2-methyl-6-t-butylphenol); 4,4'-thiobis(3-methyl-6-t-butylphenol); 2,2'-thiobis(4-methyl-6-t-butylphenol); bis(3-methyl-4-hydroxy-5-t-butylbenzyl) sulfide; bis(3,5-di-t-butyl-4-hydroxybenzyl) sulfide; n-octyl-3-(4-hydroxy-3,5-di-t-butylphenyl)propionate; n-octadecyl-3-(4-hydroxy-3,5-di-t-butylphenyl)propionate; 2,2'-thio[diethyl-bis-3-(3,5-di-t-butyl-4-hy-

droxyphenyl)propionate], etc. Of those, especially preferred are a bis-phenol-based antioxidant and an ester group-containing phenol-based antioxidant.

[0067] The amine-based antioxidant includes, for example, monoalkyldiphenylamines such as mono-octyldiphenylamine, monononyldiphenylamine, etc.; dialkyldiphenylamines such as 4,4'-dibutyldiphenylamine, 4,4'-dipentyldiphenylamine, 4,4'-dihexyldiphenylamine, 4,4'-diheptyldiphenylamine, 4,4'-dioctyldiphenylamine, 4,4'-dinonyldiphenylamine, etc.; polyalkyldiphenylamines such as tetrabutyl-diphenylamine, tetrahexyldiphenylamine, tetraoctyldiphenylamine, tetranonyldiphenylamine, etc.; naphthylamines, concretely α -naphthylamine, phenyl- α -naphthylamine and further alkyl-substituted phenyl- α -naphthylamines such as butylphenyl- α -naphthylamine, pentylphenyl- α -naphthylamine, hexylphenyl- α -naphthylamine, heptylphenyl- α -naphthylamine, octylphenyl- α -naphthylamine, nonylphenyl- α -naphthylamine, etc. Of those, diphenylamines are preferred to naphthylamines, from the viewpoint of the antioxidation effect thereof.

[0068] In the present invention, a molybdenum-amine-based antioxidant may be further added to the composition. As the molybdenum-amine-based antioxidant, for example, usable here is a product produced by allowing a hexavalent molybdenum compound, concretely molybdenum trioxide and/or molybdic acid to react with an amine compound, for example, the compounds to be produced according to the production method described in JP-A 2003-252887.

[0069] The amine compound to be reacted with a hexavalent molybdenum compound is not specifically defined. Concretely, there are mentioned monoamines, diamines, polyamines and alkanolamines. More concretely, there are exemplified alkylamines having an alkyl group with from 1 to 30 carbon atoms (in which the alkyl group may be linear or branched), such as methylamine, ethylamine, dimethylamine, diethylamine, methylethylamine, methylpropylamine, etc.; alkenylamines having an alkenyl group with from 2 to 30 carbon atoms (in which the alkenyl group may be linear or branched), such as ethenylamine, propenylamine, butenylamine, octenylamine, oleylamine, etc.; alkanolamines having an alkanol group with from 1 to 30 carbon atoms (in which the alkanol group may be linear or branched), such as methanolamine, ethanolamine, methanolethanolamine, methanolpropanolamine, etc.; alkylenediamines having an alkylene group with from 1 to 30 carbon atoms, such as methylenediamine, ethylenediamine, propylenediamine, butylenediamine, etc.; polyamines such as diethylenetriamine, triethylenetetramine, tetraethylenepentamine, pentaethylenehexamine, etc.; compounds having an alkyl or alkenyl group having from 8 to 20 carbon atoms on the above-mentioned monoamines, diamines or polyamines, such as undecyldiethylamine, undecyldiethanolamine, dodecyldipropanolamine, oleyldiethanolamine, oleylpropylenediamine, stearyl-tetraethylenepentamine, etc.; heterocyclic compounds such as imidazoline, etc.; alkylene oxide-added compounds of those compounds; mixtures of those compounds, etc. In addition, further mentioned are sulfur-containing molybdenum complexes of succinimide and the like described in JP-B 3-22438 and JP-A 2004-2866.

[0070] The amount of the antioxidant to be added to the composition is preferably from 0.5% by mass to 10% by mass based on the total amount of the composition, from the viewpoint of the miscibility thereof with base oil, more preferably from 0.5% by mass to 8% by mass, even more preferably from 0.5% by mass to 6% by mass, still more preferably from 0.5% by mass to 5% by mass. When the antioxidant is in an amount of 0.5% by mass or more based on the total amount of the composition, the acid value may be prevented from increasing, and when the antioxidant is in an amount of 5% by mass or less, the solubility in lubricant base oil may be secured.

(Pour-Point Depressant)

[0071] The pour-point depressant includes ethylene-vinyl acetate copolymers, chlorinated paraffin-naphthalene condensates, chlorinated paraffin-phenol condensates, polymethacrylates, polyalkylstyrenes, etc. For example, preferred for use herein are polymethacrylates having a mass-average molecular weight of from 5,000 to 50,000. The amount of the depressant to be in the composition is from 0.1% by mass to 5% by mass based on the total amount of the composition.

(Rust Inhibitor)

[0072] The rust inhibitor includes petroleum sulfonates, alkylbenzene sulfonates, dinonylnaphthalene sulfonates, alkenylsuccinates, polyalcohol esters, etc. The amount of the rust inhibitor is from 0.01% by mass to 1% by mass based on the total amount of the composition, preferably from 0.05% by mass to 0.5% by mass from the viewpoint of the blending effect.

(Metal Inactivator)

[0073] The metal inactivator (copper corrosion inhibitor) includes benzotriazole compounds, tolyltriazole compounds, thiadiazole compounds, imidazole compounds, pyrimidine compounds, etc. Of those, preferred are benzotriazole compounds. The metal inactivator incorporated in the composition can protect engine parts from metallic corrosion and oxidative deterioration. The amount of the metal inactivator to be added to the composition is preferably from 0.01% by

mass to 0.1% by mass based on the total amount of the composition, more preferably from 0.03% by mass to 0.05% by mass, from the viewpoint of the blending effect.

(Defoaming Agent)

[0074] The defoaming agent includes silicone oils, fluorosilicone oils, fluoroalkyl ethers, etc. From the viewpoint of the balance between the defoaming effect and the economic efficiency, the defoaming agent is incorporated in the composition in an amount of from 0.005% by mass to 0.1% by mass based on the total amount of the composition.

(Anti-Wear Agent or Extreme-Pressure Agent)

[0075] The anti-wear agent or the extreme-pressure agent includes sulfur-containing compounds such as zinc dithiophosphate, zinc phosphate, zinc dithiocarbamate, molybdenum dithiocarbamate, molybdenum dithiophosphate, disulfides, sulfurized olefins, sulfurized oils and fats, sulfurized esters, thiocarbonates, thiocarbamates, polysulfides, etc.; phosphorus-containing compounds such as phosphites, phosphates, phosphonates, amine salts or metal salts of those compounds, etc.; sulfur and phosphorus-containing anti-wear agents such as thiophosphites, thiophosphates, thiophosphonates, amine salts or metal salts of those compounds, etc.

[0076] In case where the anti-wear agent or extreme-pressure agent is optionally incorporated in the composition, the amount of the agent is preferably from 500 ppm by mass to 1000 ppm by mass in terms of the zinc element therein and based on the total weight of the lubricating oil composition.

[0077] Also preferably, the amount of the anti-wear agent or extreme-pressure agent is from 500 ppm by mass to 1000 ppm by mass in terms of the phosphorus element therein and based on the total weight of the lubricating oil composition, more preferably from 600 ppm by mass to 950 ppm by mass, even more preferably from 700 ppm by mass to 950 ppm by mass. The lubricating oil composition of the present invention having a zinc content of from 500 ppm by mass to 1000 ppm by mass and a phosphorus content of from 500 ppm by mass to 1000 ppm by mass realizes wear amount reduction and fuel efficiency improvement in internal-combustion engines.

[Properties of Lubricating Oil Composition]

[0078] In the lubricating oil composition of this embodiment, the calcium amount derived from the metallic detergent therein is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition.

[0079] The high-temperature high-shear viscosity at 150°C of the lubricating oil composition is 2.6 mPa·s or more. A lubricating oil composition having a high-temperature high-shear viscosity at 150°C of less than 2.6 mPa·s may cause oil film fracture. In addition, the polymer used as a viscosity index improver may fracture to provide permanent viscosity reduction that would be unrestorable even when the temperature of the lubricating oil composition lowers.

[0080] The high-temperature high-shear viscosity at 80°C of the lubricating oil composition is 7.8 mPa·s or less. Using a lubricating oil composition having a high-temperature high-shear viscosity at 80°C of more than 7.8 mPa·s, the fuel efficiency of internal-combustion engines in a temperature range of 80°C would worsen.

[0081] The ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof must be 2.05 or less.

[0082] When the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less, then the composition can maintain or improve the detergency thereof not requiring increase in the amount of the ash-free dispersant therein, even when the amount of the metallic detergent therein is reduced so that the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition.

[0083] The high-temperature high-shear viscosity of the lubricating oil composition at 150°C is 2.6 mPa·s or more and the ratio of the high-temperature high-shear viscosity at 100°C to the high-temperature high-shear viscosity at 150°C thereof is more than 2.05. This means that the viscosity resistance at 100°C of the composition is large. In other words, when a lubricating oil composition has a ratio of the high-temperature high-shear viscosity at 100°C to the high-temperature high-shear viscosity at 150°C thereof of more than 2.05, fuel efficiency in a temperature range of 100°C worsens.

[0084] When the ratio of HTHS viscosity at 100°C to HTHS viscosity at 150°C is lowered too much, then the detergency of the composition worsens, and therefore, the lower limit of the ratio HTHS viscosity at 100°C to HTHS viscosity at 150°C is 1.80.

[0085] The high-temperature high-shear viscosity at 150°C of the lubricating oil composition and the high-temperature high-shear viscosity at 100°C thereof coming to be close to each other, that is, the ratio coming to be nearer to 1 means that the viscosity resistance of the composition at 100°C can be lowered. In this case, for example, fuel efficiency in running in a medium speed range can be increased.

[0086] Preferably, the lubricating oil composition of this embodiment is such that the NOACK value thereof, as measured

in the NOACK test at 250°C for 1 hour according to ASTM D 5800, is 13% by mass or less. When having an NOACK value of 13% by mass or less, the consumption of the lubricating oil composition can be reduced and therefore sludge would hardly form.

[0087] From this viewpoint, the NOACK value is more preferably 12% by mass or less, even more preferably 11% by mass or less. From the viewpoint that the consumption reducing effect of the lubricating oil composition would reach a ceiling, the lower limit of the NOACK value is 6% by mass.

[0088] Irrespective of the structures of the polymethacrylate viscosity index improver and the olefin copolymer viscosity index improver therein and using both the two, the lubricating oil composition of this embodiment is so planned that the high-temperature high-shear viscosity at 80°C thereof is 7.8 mPa·s or less, that the high-temperature high-shear viscosity at 150°C thereof is 2.6 mPa·s or more and that the ratio of the high-temperature high-shear viscosity at 100°C to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less, and therefore exhibits excellent fuel efficiency, durability and piston detergency.

<Phosphorus Content and Sulfate Ash Content in Lubricating Oil Composition>

[0089] The phosphorus content in the lubricating oil composition of the present invention is preferably from 500 ppm by mass to 1000 ppm by mass based on the total amount of the lubricating oil composition. Having a phosphorus content of from 500 ppm by mass to 1000 ppm by mass, the composition attains sufficient anti-wear performance. From this viewpoint, the phosphorus content is more preferably from 600 ppm by mass to 950 ppm by mass, even more preferably from 700 ppm by mass to 950 ppm by mass.

[0090] The sulfate ash content in the lubricating oil composition of the present invention is preferably from 0.4% by mass to 0.8% by mass based on the total amount of the composition. Having a sulfate ash content falling within the range, the composition realizes reduction in the amount of ash to deposit on DPF filters when applied to diesel engines and therefore prevents DPF filters from clogging with ash to thereby contribute toward prolongation of the life of DPF filters.

[0091] The sulfate ash content means the ash content as determined by adding sulfuric acid to the carbonized residue formed in burning a sample followed by heating it to have a constant weight, and is generally used as an index of indicating the approximate amount of the metallic additives in lubricating oil compositions. Concretely, the sulfate ash content is measured according to the method defined in JIS K 2272 "5. Test Method for Sulfate Ash Content".

Examples

[0092] The present invention is described in more detail with reference to the following Examples. The present invention is not limited to the following Examples.

[Properties Measurement of Lubricating Oil Composition]

(1) Kinematic Viscosity (at 40°C and 100°C)

[0093] Measured according to ASTM D445.

(2) Viscosity Index of Base Oil

[0094] Measured according to "Test Method for Kinematic Viscosity of Petroleum Products" defined in JIS K 2283.

(3) CCS Viscosity of Composition

[0095] Measured according to ASTM D2602.

(4) NOACK Value of Composition

[0096] Measured according to ASTM D5800.

(5) HTHS Viscosity (high-temperature high-shear viscosity), at 80°C, 100°C, 150°C

[0097] Measured according to ASTM D4683.

(6) Phosphorus and Calcium Content

[0098] Measured according to JPI-5S-38-92.

5 [Properties Evaluation]

<Panel Coking Test>

10 **[0099]** 300 ml of a sample oil was heated in a heating tank at 100°C, and splashed on an aluminium plate arranged on the top of the heating tank and heated at 300°C using feathers, and this operation was continued for 3 hours. After 3 hours, the mass of the deposit adhering to the aluminium plate was measured.

<Residual Base Value after ISOT>

15 **[0100]** Measured according to JIS K2514.

<Shell Four-Ball Test>

20 **[0101]** Measured according to ASTM D2783.

<Engine Motoring Torque Test>

25 **[0102]** A commercially-available 1.8-liter engine was driven with an external motor, and the torque necessary for the driving was measured. Regarding the oil/water temperature of the lubricating oil composition charged inside the engine, the oil temperature and the water temperature were set at 80°C on the assumption of actual running.

[0103] The engine rotation number was set at 1500 rpm, and the torque at the rotation number was measured. It is considered that, when the measured engine driving torque is smaller, the fuel efficiency of the charged lubricating oil composition is better.

30 [Examples and Comparative Examples]

35 **[0104]** Using a base oil, a dispersant, a metallic detergent and other additives, sample oils of lubricating oil compositions of Examples 1 and 2 and Comparative Examples 1 to 4 were prepared, and according to the above-mentioned evaluation methods, these sample oils were measured for the characteristics and the properties thereof. The results are shown in Table 1. Lubricating oil compositions of Examples 3 and 4 and Comparative Examples 5 and 6 were prepared in the same manner as in Example 1 except for changing the calcium amount based on the total amount of the lubricating oil composition, and according to the above-mentioned evaluation methods, these were measured for the characteristics and the properties thereof. The results are shown in Table 2. For comparison, the results of Example 2 are shown in Table 2.

40 **[0105]** Table 3 shows the ratio of the high-temperature high-shear viscosity at 100°C of different lubricating oil compositions, which had been prepared using different PMA viscosity index improvers, to the high-temperature high-shear viscosity at 150°C thereof.

45

50

55

Table 1

			Example 1	Example 2	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
		(mass%)	balance	balance	balance	balance	balance	balance
Lubricating Oil Composition	Mineral Oil*1	(mass%)	10.00	10.00	10.00	10.00	10.00	10.00
	Synthetic Oil *2	(mass%)	4.80	7.20	0.00	2.40	9.60	12.00
	PMA Viscosity Index Improver*3	(mass%)	10.40	6.20	17.70	13.90	3.10	0.00
	OCP Viscosity Index Improver*4	(mass%)	2.36	2.36	2.36	2.36	2.36	2.36
	Metallic Detergent *5	(mass%)	12.25	12.25	12.25	12.25	12.25	12.25
	Additive Package *6	(mass%)	36.5	35.0	39.0	37.8	34.2	33.8
Properties	40°C Kinematic Viscosity	(mm ² /s)	8.0	7.8	8.2	8.1	7.7	7.7
	100°C Kinematic Viscosity	(mm ² /s)	201	203	192	196	205	208
	Viscosity Index		≤6200	≤6200	≤6200	≤6200	≤6200	≤6200
	CCS Viscosity	(mPa·s)	≤13	≤13	≤13	≤13	≤13	≤13
	NOACK Test	(mass%)	7.7	7.2	8.2	7.9	6.8	6.5
	HTHS Viscosity 80°C	(mPa·s)	5.3	5.1	5.5	5.4	4.9	4.8
	HTHS Viscosity 100°C	(mPa·s)	2.6	2.6	2.6	2.6	2.6	2.6
	HTHS Viscosity 150°C	(mPa·s)	0.09	0.09	0.09	0.09	0.09	0.09
	Phosphorus Content (based on lubricating oil composition)	(mass%)	0.12	0.12	0.12	0.12	0.12	0.12
	Calcium Content (based on lubricating oil composition)	(mass%)	2.04	1.96	2.12	2.08	1.88	1.85

(continued)

Evaluation Results	Engine Motoring Torque Test	Nm	Example 1	Example 2	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
	Torque Reduction	%	0.60	0.84	0.00	0.36	1.20	1.20
	Panel Coking Test	mg	84	95	67	79	120	127
	Residual Base Value after ISOT	mg KOH/g	-	0.67	-	-	-	-
	Shell Four-Ball Test	mm	-	0.38	-	-	-	-

EP 2 905 323 A1

Table 2

			Example 2	Example 3	Example 4	Comparative Example 5	Comparative Example 6
5	Lubricating Oil Composition	Mineral Oil*1	(mass%)	balance	balance	balance	balance
		Synthetic Oil*2	(mass%)	10.00	10.00	10.00	10.00
10		PMA Viscosity Index Improver*3	(mass%)	7.20	7.20	7.20	7.20
		OCP Viscosity Index Improver*4	(mass%)	6.20	6.20	6.20	6.20
15		Metallic Detergent*5	(mass%)	2.36	0.98	2.95	0.00
		Additive Package *6	(mass%)	12.25	12.25	12.25	12.25
20	Properties	40°C Kinematic Viscosity	(mm ² /s)	35.0	34.5	35.8	34.0
		100°C Kinematic Viscosity	(mm ² /s)	7.8	7.7	7.9	7.6
25		Viscosity Index		203	202	202	202
		CCS Viscosity	(mPa·s)	≤6200	≤6200	≤6200	≤6200
30		NOACK Test	(mass%)	≤13	≤13	≤13	≤13
		HTHS Viscosity 80°C	(mPa·s)	7.2	7.2	7.4	7.2
35		HTHS Viscosity 100°C	(mPa·s)	5.1	5.1	5.2	5.1
		HTHS Viscosity 150°C	(mPa·s)	2.6	2.6	2.6	2.6
40		Phosphorus Content (based on lubricating oil composition)	(mass%)	0.09	0.09	0.09	0.09
45		Calcium Content (based on lubricating oil composition)	(mass%)	0.12	0.05	0.15	0.00
50		Ratio of 100°C HTHS Viscosity to 150°C HTS Viscosity		1.96	1.96	2.00	1.96
55							

EP 2 905 323 A1

(continued)

			Example 2	Example 3	Example 4	Comparative Example 5	Comparative Example 6
5	Evaluation Results	Engine Motoring Torque Test	Nm	8.27	-	-	-
10		Torque Reduction	%	0.84	-	-	-
		Panel Coking Test	mg	95	-	-	-
15		Residual Base Value after ISOT	mg KOH/g	0.67	0.31	0.95	0.00
		Shell Four-Ball Test	mm	0.38	0.37	0.38	0.36
20							

Table 3

			Comparative Example 7	Comparative Example 8	Example 5
25	Lubricating Oil Composition	Mineral Oil*1	(mass%)	balance	balance
		Synthetic Oil*2	(mass%)	10.00	10.00
		PMA Viscosity Index Improver*7	(mass%)	10.70	0.00
30		PMA Viscosity Index Improver*8	(mass%)	0.00	7.76
		PMA Viscosity Index Improver*9	(mass%)	0.00	0.00
		OCP Viscosity Index Improver*4	(mass%)	3.1	3.1
35		Metallic Detergent*5	(mass%)	2.36	2.36
		Additive Package *6	(mass%)	12.25	12.25
40	Properties	40°C Kinematic Viscosity	(mm ² /s)	37.5	38.9
		100°C Kinematic Viscosity	(mm ² /s)	7.9	8.4
		Viscosity Index		189	201
		CCS Viscosity	(mPa·s)	≤6200	≤6200
		NOACK Test	(mass%)	≤13	≤13
45		HTHS Viscosity 80°C	(mPa·s)	11.0	7.9
		HTHS Viscosity 100°C	(mPa·s)	6.6	5.4
		HTHS Viscosity 150°C	(mPa·s)	2.6	2.6
50		Phosphorus Content (based on lubricating oil composition)	(mass%)	0.09	0.09
		Calcium Content (based on lubricating oil composition)	(mass%)	0.12	0.12
55		Ratio of 100°C HTHS Viscosity to 150°C HTHS Viscosity		2.54	2.08

[0106] Notes in Table 1 and Table 2 are as follows:

*1: Paraffinic mineral oil: grade 100 N (40°C kinematic viscosity 17.9 mm²/s, 100°C kinematic viscosity 4.1 mm²/s, viscosity index 131, % C_p = 87.4%, density 0.825 g/cm³)

*2: PAO: poly-alpha-olefin (40°C kinematic viscosity 25.1 mm²/s, 100°C kinematic viscosity 5.1 mm²/s, viscosity index 141, density 0.824 g/cm³)

*3: PMA viscosity index improver (non-dispersant type polymethacrylate polymer, Mw = 370,000)

*4: OCP viscosity index improver (non-dispersant type olefin copolymer polymer, Mw = 100, 000)

*5: Neutral calcium sulfonate, overbased calcium phenate

*6: The additive package is an additive prepared by removing the metallic detergent from a package according to ACEA/C2, JASO DL-1 Standards. This contains ZnDTP (Prim. +Sec type) as anti-wear agent, polymer bis-type imide as dispersant, diphenylamine and hindered phenol as antioxidant, benzotriazole as metal inactivator, and silicone defoaming agent as defoaming agent.

*7: PMA viscosity index improver (non-dispersant type polymethacrylate polymer, Mw = 30,000)

*8: PMA viscosity index improver (non-dispersant type polymethacrylate polymer, Mw = 200,000)

*9: PMA viscosity index improver (non-dispersant type polymethacrylate polymer, Mw = 420,000)

[Evaluation Results]

[0107] From the results shown in Table 1 and Table 2, it can be seen that, when the ratio of the HTHS viscosity at 100°C of the lubricating oil composition to the HTHS viscosity at 150°C thereof is 2.05 or less, then the degree of torque reduction (that is, rate of improvement) is high, and the composition contributes toward increasing fuel efficiency.

[0108] From the results shown in Table 3, it can be seen that, by changing the type of the PMA viscosity index improver, the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof can be controlled.

[0109] From the above, it can be seen that the lubricating oil composition of the present invention satisfies high-level fuel efficiency and durability.

Industrial Applicability

[0110] The lubricating oil composition of the present invention is favorably used as a lubricating oil composition for internal-combustion engines having, as mounted thereon, any of exhaust gas filters such as diesel particulate filters, gasoline particulate filters and the like and exhaust-gas aftertreatment devices such as ternary catalysts, oxidation catalysts, etc.

Claims

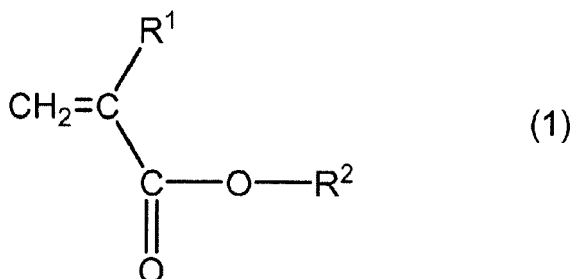
1. A lubricating oil composition comprising a viscosity index improver and a metallic detergent in at least one base oil selected from mineral oils and synthetic oils therein:

wherein the viscosity index improver contains a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver,
the polymethacrylate viscosity index improver is contained in an amount of from 3.0% by mass to 9.5% by mass based on the total amount of the lubricating oil composition,
the metallic detergent contains at least one selected from calcium sulfonate, calcium phenate and calcium salicylate,
the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition,
the high-temperature high-shear viscosity at 150°C of the lubricating oil composition is 2.6 mPa·s or more, the high-temperature high-shear viscosity at 80°C of the lubricating oil composition is 7.8 mPa·s or less,
and the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less.

2. The lubricating oil composition according to claim 1, wherein the NOACK value, as measured in the NOACK test at 250°C for 1 hour according to ASTM D 5800, is 13% by mass or less.

3. The lubricating oil composition according to claim 1 or 2, wherein the polymethacrylate viscosity index improver is a non-dispersant type polymethacrylate viscosity index improver.

4. The lubricating oil composition according to claim 3, wherein the non-dispersant type polymethacrylate viscosity index improver is a non-dispersant type poly(meth)acrylate compound obtainable by homopolymerization of one monomer represented by the general formula (1) or copolymerization of two or more of the monomers represented by the general formula (1):



wherein R¹ represents a hydrogen atom or a methyl group, and R² represents a linear or branched hydrocarbon group having from 1 to 200 carbon atoms.

5. The lubricating oil composition according to any of claims 1 to 4, wherein the weight-average molecular weight of the polymethacrylate viscosity index improver is from 100,000 to 500,000.
6. The lubricating oil composition according to any of claims 1 to 5, wherein the content of the olefin copolymer viscosity index improver is from 30 parts by mass to 250 parts by mass relative to 100 parts by mass of the polymethacrylate viscosity index improver.
7. The lubricating oil composition according to any of claims 1 to 6, wherein the olefin copolymer viscosity index improver is selected from the group consisting of a styrene-diene hydrogenated copolymer, an ethylene- α -olefin copolymer, a hydrogenated derivative of an ethylene- α -olefin copolymer, a polyisobutylene, a hydrogenated derivative of a polyisobutylene, a polyalkylstyrene, and mixtures thereof.
8. The lubricating oil composition according to any of claims 1 to 7, wherein the olefin copolymer viscosity index improver has a weight-average molecular weight of from 10,000 to 800,000.
9. The lubricating oil composition according to any of claims 1 to 8, wherein the content of the olefin copolymer viscosity index improver is from 2% by mass to 12.0% by mass based on the total amount of the lubricating oil composition.
10. The lubricating oil composition according to any of claims 1 to 9, which comprises an antioxidant selected from a phenol-based antioxidant and an amine-based antioxidant in an amount of from 0.5% by mass to 10% by mass based on the total amount of the lubricating oil composition.
11. A method for producing a lubricating oil composition, which comprises:

incorporating a viscosity index improver that contains a polymethacrylate viscosity index improver and an olefin copolymer viscosity index improver so that the amount of the polymethacrylate viscosity index improver is from 3.0% by mass to 9.5% by mass based on the total amount of the lubricating oil composition, and a metallic detergent containing at least one selected from calcium sulfonate, calcium phenate and calcium salicylate, in at least one base oil selected from mineral oils and synthetic oils:

so that the calcium amount derived from the metallic detergent is from 500 ppm to 1500 ppm based on the total amount of the lubricating oil composition, that the high-temperature high-shear viscosity at 150°C of the lubricating oil composition is 2.6 mPa·s or more, that the high-temperature high-shear viscosity at 80°C of the lubricating oil composition is 7.8 mPa·s or less, and that the ratio of the high-temperature high-shear viscosity at 100°C of the lubricating oil composition to the high-temperature high-shear viscosity at 150°C thereof is 2.05 or less.



EUROPEAN SEARCH REPORT

Application Number
EP 15 15 3425

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 439 256 A1 (JX NIPPON OIL & ENERGY CORP [JP]) 11 April 2012 (2012-04-11) * paragraph [0001] - paragraph [0007] * * paragraph [0051] - paragraph [0067] * * paragraph [0046] - paragraph [0078] * * claims; examples *	1-11	INV. C10M169/04
A	EP 2 112 217 A1 (NIPPON OIL CORP [JP]) 28 October 2009 (2009-10-28) * paragraph [0004] - paragraph [0010] * * paragraph [0032] - paragraph [0057] * * paragraph [0077] - paragraph [0093] * * claims; examples *	1-11	
			TECHNICAL FIELDS SEARCHED (IPC)
			C10M C10N
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 June 2015	Examiner Elflein, Eleonore
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 15 15 3425

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

30-06-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2439256 A1	11-04-2012	CN 102459537 A	16-05-2012
		EP 2439256 A1	11-04-2012
		JP 2010280822 A	16-12-2010
		US 2012071374 A1	22-03-2012
		WO 2010140392 A1	09-12-2010

EP 2112217 A1	28-10-2009	EP 2112217 A1	28-10-2009
		JP 5565999 B2	06-08-2014
		JP 2008184569 A	14-08-2008
		US 2010093578 A1	15-04-2010
		WO 2008093446 A1	07-08-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 4965228 B [0007]
- JP 2010280821 A [0007]
- JP 2003252887 A [0068]
- JP 3022438 B [0069]
- JP 2004002866 A [0069]