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(54) **LUBRICANT OIL COMPOSITION**

(57) Provided is a lubricating oil composition favorable for reducing friction in a sliding mechanism equipped with a piston ring and a liner, in a device having the sliding mechanism. The lubricating oil composition contains a lubricant base oil, (1) a polymethacrylate and/or an olefin

copolymer having a mass-average molecular weight of 100,000 to 600,000, and (2) an ester-type ashless friction modifier and/or an amine-type ashless friction modifier, and has a shear viscosity at 150°C of 2.3 mPa·s or more and less than 3.7 mPa·s.

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Description

Technical Field

5 **[0001]** The present invention relates to a lubricating oil composition, in particular to a lubricating oil composition favorable for reducing friction in a device equipped with a piston ring and a liner, especially to a lubricating oil composition for internal combustion engines with improved fuel-saving performance.

Background Art

10 **[0002]** From the viewpoint of environmental load reduction, it is desired to reduce CO₂ to be emitted by automobiles for suppressing global warming, and it is desired to improve further fuel-saving performance of lubricating oil for internal combustion engines of automobiles, etc. For improving fuel-saving performance of lubricating oil for internal combustion engines, improvement and viscosity reduction in point of composition of lubricating oil are being under way in the region
15 of fluid lubrication (for example, PTLs 1 and 2). However, mere lubricating oil viscosity reduction is problematic in point of lubrication insufficiency (friction increase) in a severe lubrication environment such as sliding between a piston ring and a liner, and therefore, optimal technique for formulating a lubricating oil is further desired. On the other hand, from the viewpoint of improvement of fuel efficiency of engines, down-sized lightweight high-power engines are being popular, but also in this case, there still exist concerns about insufficient lubricity between a piston ring and a liner with increase
20 in thermal load. PTL 3 tries to attain friction reduction and an excellent fuel-saving effect from the viewpoint of both materials of a piston ring of an engine and a lubricating oil, but even with such a lubricating oil, the lubricity between a piston ring and a liner is still insufficient.

Citation List

25 Patent Literature

[0003]

30 PTL 1: Japanese Patent 5044093
PTL 2: Japanese Patent 4643030
PTL 3: JP 2005-2888 A

Summary of Invention

35 Technical Problem

[0004] As described above, from the viewpoint of improvement of fuel-saving performance of a lubricating oil (engine oil) for internal combustion engines, investigations for viscosity reduction for reducing friction resistance (viscosity reduction in a practical range) in the region of fluid lubrication are being promoted. However, in lubrication for sliding
40 between a piston ring and a liner, there exist both a fluid lubrication region and a boundary lubrication region as mixed, and under the condition, mere viscosity reduction of an engine oil would result in dominant boundary lubrication and there would be a risk of friction resistance increase. Accordingly, a lubricating oil composition having an optimal formulation capable of imparting excellent low friction characteristics to sliding between a piston ring and a liner is desired.

45 **[0005]** Specifically, an object of the present invention is to provide a lubricating oil composition favorable for friction reduction in a sliding mechanism equipped with a piston ring and a liner, in a device having the sliding mechanism.

Solution to Problem

50 **[0006]** As a result of assiduous studies made in consideration of the above-mentioned problems, the present inventors have found that, when a lubricating oil composition is controlled to have a shear viscosity falling within a specific high-temperature shear viscosity range and controlled to contain a lubricant base oil, (1) a polymethacrylate and/or an olefin copolymer having a specific molecular weight and (2) a specific friction modifier, the lubricating oil composition can reduce friction resistance in any of a fluid lubrication region and a mixed lubrication region to improve lubricity and, as
55 a result, even when used in a device having a sliding mechanism equipped with a piston ring and a liner, the lubricating oil composition can greatly reduce the friction resistance against the thermal load increase in the device and can maintain lubricity therein, and thus have completed the present invention.

[0007] Specifically, the present invention is as follows.

[0008]

[1] A lubricating oil composition for use in a device having a sliding mechanism equipped with a piston ring and a liner, which contains a lubricant base oil, (1) a polymethacrylate and/or an olefin copolymer having a mass-average molecular weight of 100,000 to 600,000, and (2) an ester-type ashless friction modifier and/or an amine-type ashless friction modifier, and has a shear viscosity at 150°C of 2.3 mPa·s or more and less than 3.7 mPa·s.

[2] The lubricating oil composition according to the above [1], wherein the mass-average molecular weight of the polymethacrylate and/or the olefin copolymer (1) is 200,000 to 550,000.

[3] The lubricating oil composition according to the above [1] or [2], wherein the content of the polymethacrylate and/or the olefin copolymer (1) is 2.5% by mass or more and less than 15% by mass based on the total amount of the composition.

[4] The lubricating oil composition according to any one of the above [1] to [3], wherein the content of the ashless friction modifier is 0.1% by mass or more and less than 2% by mass based on the total amount of the composition.

[5] The lubricating oil composition according to any one of the above [1] to [4], wherein the viscosity index of the lubricant base oil is 120 or more.

[6] The lubricating oil composition according to any one of the above [1] to [5], wherein the phosphorus content is 0.12% by mass or less based on the total amount of the composition.

[7] The lubricating oil composition according to any one of the above [1] to [6], which contains a Ca-containing metallic detergent and/or a Mg-containing metallic detergent in an amount of 0.05% by mass or more and 0.30% by mass or less as a total amount of Ca and Mg based on the total amount of the composition.

[8] The lubricating oil composition according to any one of the above [1] to [7], which contains polybutenylsuccinic imide and/or a boronated polybutenylsuccinic imide.

[9] The lubricating oil composition according to any one of the above [1] to [8], which is for internal combustion engines.

[10] The lubricating oil composition according to any one of the above [1] to [9], wherein the piston ring in a sliding mechanism equipped with a piston ring and a liner is one treated with chromium nitride.

[11] A method for producing the lubricating oil composition of any one of the above [1] to [10], which includes a step of blending a lubricant base oil with (1) a polymethacrylate and/or a olefin copolymer having a mass-average molecular weight of 100,000 to 600,000 stated above and (2) an ester-type ashless friction modifier and/or an amine-type ashless friction modifier stated above.

[12] A method of lubricating a device having a sliding mechanism equipped with a piston ring and a liner, which includes lubricating a device having a sliding mechanism equipped with a piston ring and a liner with the lubricating oil composition of any one of the above [1] to [10].

Advantageous Effects of Invention

[0009] According to the present invention, there can be provided a lubricating oil composition favorable for reducing friction in a sliding mechanism equipped with a piston ring and a liner, in a device having the sliding mechanism.

Brief Description of Drawing

[0010] Fig. 1 is a schematic view showing an outline of a floating liner friction tester for measuring the friction force between a piston ring and a liner.

Description of Embodiments

[0011] The present invention is described in more detail hereinafter.

[Lubricating oil composition]

[0012] The lubricating oil composition of the present invention is a lubricating oil composition for use in a device having a sliding mechanism equipped with a piston ring and a liner, which contains a lubricant base oil, (1) a polymethacrylate and/or an olefin copolymer having a mass-average molecular weight of 100,000 to 600,000, and (2) an ester-type ashless friction modifier and/or an amine-type ashless friction modifier, and has a shear viscosity at 150°C of 2.3 mPa·s or more and less than 3.7 mPa·s.

[0013] The lubricating oil composition of the present invention, when used in a device having a sliding mechanism equipped with a piston ring and a liner, can reduce the friction resistance of the sliding mechanism.

[0014] Specifically, in general, in lubrication for sliding between a piston ring and a liner, in particular, the lubrication is likely to be performed as a boundary lubrication region at around the top dead center and the bottom dead center of

the piston. Consequently, mere reduction in the viscosity of a lubricating oil composition for reducing the friction in a fluid lubrication region causes dominant boundary lubrication at around the top dead center and the bottom dead center, therefore resulting in increase in the friction resistance therein. In addition, when the viscosity of a lubricating oil composition is lowered, the friction resistance at a low temperature (around 30°C) could be low but the friction resistance at a high temperature (around 90°C) may increase. On the other hand, when the viscosity of a lubricating oil composition is increased, the friction resistance at a high temperature could be low but the friction resistance at a low temperature may increase. Consequently, it has been difficult to reduce the friction resistance from a low-temperature range to a high-temperature range.

[0015] Given the situation, the present inventors measured the friction energy of lubricating oil compositions prepared by blending various materials, using a floating liner friction tester to be mentioned below. As a result, the present inventors have found that, when a polymethacrylate and an olefin copolymer are selected as materials for a lubricating oil composition and when the molecular weight of the materials is changed, the effect of the lubricating oil composition for reducing friction energy at a low temperature and/or a high temperature varies. In addition, the inventors have found that, when the kind of the friction modifier to be used along with the polymethacrylate and/or the olefin copolymer is changed, the effect of the lubricating oil composition for reducing friction energy at a low temperature and/or a high temperature varies.

[0016] More specifically, the inventors have found that, when a lubricating oil composition in which the molecular weight of the polymethacrylate is low and oversteps the scope of the present invention is used, the friction energy at a low temperature (liner temperature of 30°C) is high. In turn, the inventors have also found that a lubricating oil composition containing an ether-type friction modifier that is outside the scope of the present invention is used, the friction energy at a liner temperature of 90°C is high. Further, the inventors have found that, in the case where the high-temperature shear viscosity (150°C) oversteps the scope of the present invention, the friction energy at a liner temperature of 30°C or 90°C is high in any case.

[0017] The present invention has been created on the basis of these findings, and the lubricating oil composition contains, as described above, a polymethacrylate and/or an olefin copolymer whose molecular weight falls within a specific range, and a specific kind of a friction modifier, and has a high-temperature shear viscosity (150°C) falling within a predetermined range. Accordingly, using the lubricating oil composition of the present invention, the friction resistance at a low temperature (around 30°C) and a friction resistance at a high temperature (around 90°C) can be reduced. Consequently, when the lubricating oil composition is used in a device having a sliding mechanism equipped with a piston ring and a liner, the friction resistance can be reduced not only in a fluid lubrication region but also in a boundary lubrication region.

(Lubricant base oil)

[0018] The lubricant base oil for use in the lubricating oil composition of the present invention is not specifically limited, and any base oil composed of a mineral oil and/or a synthetic oil is usable. The kinematic viscosity of the base oil at 100°C is preferably 7 mm²/s or less, more preferably 6 mm²/s or less. When the kinematic viscosity at 100°C is 7 mm²/s or less, the fuel-saving performance can be realized without increasing the friction coefficient in a fluid lubrication region. On the other hand, the kinematic viscosity at 100°C is preferably 2 mm²/s or more, more preferably 3 mm²/s or more. When the kinematic viscosity at 100°C is 2 mm²/s or more, lubricity, such as wear-resistant properties and the like, necessary for slide portions such as valve train systems, pistons, rings, bearings and the like in internal combustion engines can be secured.

[0019] Examples of mineral base oils include those refined by subjecting a lubricating oil distillate that is obtained by distilling a crude oil under atmospheric pressure or by distilling under reduced pressure the atmospheric residue given by atmospheric distillation of a crude oil, to one or more treatments selected from solvent deasphalting, solvent extraction, hydro-cracking, solvent dewaxing, hydrotreating and the like, and those produced by isomerization of a mineral oil wax or a wax produced through Fischer-Tropsch synthesis or the like (gas-to-liquid wax).

[0020] These mineral base oils preferably have a viscosity index of 90 or more, more preferably 100 or more, even more preferably 120 or more. When the viscosity index is not lower than the above value, the low-temperature viscosity of the composition can be reduced to realize fuel saving and the high-temperature viscosity thereof can be increased to secure lubricity at a high temperature. The viscosity index can be measured according to JIS K 2283.

[0021] The aromatic content (%C_A) in the mineral base oil is preferably 3 or less, more preferably 2 or less, even more preferably 1 or less. The sulfur content is preferably 100 ppm by mass or less, more preferably 50 ppm by mass or less. When the aromatic content is 3 or less and the sulfur content is 100 ppm by mass or less, the oxidation stability of the composition can be kept good.

[0022] On the other hand, examples of synthetic base oils include polybutene or a hydride thereof, poly- α -olefins, such as 1-decene oligomer, etc., or hydrides thereof, diesters such as di-2-ethylhexyl adipate, di-2-ethylhexyl sebacate, etc., polyol esters such as trimethylolpropane caprylate, pentaerythritol 2-ethylhexanoate, etc., aromatic synthetic oils

such as alkylbenzenes, alkylnaphthalenes, etc., polyalkylene glycols, or mixtures thereof.

[0023] In the present invention, any of mineral base oils, synthetic base oils, or mixtures of any two or more selected from these can be used as the base oil.

[0024] The content of the base oil in the lubricating oil composition of the present invention is preferably 60% by mass or more, more preferably 70% by mass or more, even more preferably 75% by mass or more, and is preferably 90% by mass or less, more preferably 85% by mass or less, even more preferably 80% by mass or less.

((1) Polymethacrylate and/or olefin copolymer)

[0025] In the lubricating oil composition of the present invention, a polymethacrylate having a mass-average molecular weight of 100,000 to 600,000 and/or an olefin copolymer having a mass-average molecular weight of 100,000 to 600,000 are blended especially for imparting an excellent friction-reducing effect to a sliding mechanism equipped with a piston ring and a liner.

[0026] In the present invention, from the viewpoint of realizing an excellent friction-reducing effect, a polymethacrylate having a mass-average molecular weight of 200,000 to 550,000 is preferably used. One alone or two or more such polymethacrylates may be used either singly or as combined.

[0027] The mass-average molecular weight (Mw) can be measured, for example, according to the following method. Specifically, according to a gel permeation chromatography (GPC) method and using an apparatus under the condition mentioned below, a polystyrene-equivalent mass-average molecular weight of the polymer is measured, and the measured value can be denoted as a mass-average molecular weight (Mw) thereof.

<GPC apparatus>

[0028]

Column: TOSO GMHHR-H(S)HT

Detector: RI detector for liquid chromatography, WATERS 150C

<Measurement condition>

[0029]

Solvent: 1,2,4-trichlorobenzene

Measurement temperature: 145°C

Flow rate: 1.0 mL/min

Sample concentration: 2.2 mg/mL

Injection amount: 160 µL

Calibration curve: Universal Calibration

Analysis program: HT-GPC (Ver. 1.0)

[0030] Examples of the olefin copolymer usable here include ethylene-propylene copolymers, ethylene-butylene copolymers, styrene-isoprene copolymers, styrene-butadiene copolymers, etc.

[0031] The olefin copolymer may be used in combination with the above-mentioned polymethacrylate.

[0032] The polymethacrylate and the olefin copolymer each have a mass-average molecular weight of 100,000 to 600,000. When the mass-average molecular weight is lower than 100,000, in particular, the friction-reducing effect in a sliding mechanism equipped with a piston ring and a liner is low, but when it is more than 600,000, the friction-reducing effect on a high-temperature side is difficult to realize, and in any case, it is difficult to stably maintain the effect. From this viewpoint, the mass-average molecular weight of the polymethacrylate and the olefin copolymer is preferably 200,000 to 550,000 each, even more preferably 220,000 to 520,000 each. The mass-average molecular weight can be obtained from a calibration curve formed through gel permeation chromatography using polystyrene.

[0033] The content of the polymethacrylate and the olefin copolymer is preferably selected within a range of 2.5% by mass or more and less than 15% by mass based on the total amount of the composition. When the content is 2.5% by mass or more, in particular, an excellent friction-reducing effect in a sliding mechanism equipped with a piston ring and a liner can be realized, and when it is less than 15% by mass, an excellent friction-reducing effect can be realized with no problem of viscosity increase at a low temperature, and in any case, the effect can be maintained stably. From the above-mentioned viewpoint, the content of the polymethacrylate and the olefin copolymer (1) is more preferably 3.5% by mass or more and 13.5% by mass or less based on the total amount of the composition.

((2) Friction modifier)

[0034] The lubricating oil composition of the present invention contains an ester-type ashless friction modifier and/or an amine-type ashless friction modifier especially for securing an excellent friction-reducing effect in a sliding mechanism equipped with a piston ring and a liner.

[0035] As the ester-type ashless friction modifier and/or the amine-type ashless friction modifier, for example, an aliphatic ester or an aliphatic amine having at least one of an alkyl group and an alkenyl group having 6 to 30 carbon atoms in the molecule can be used. The alkyl group and the alkenyl group each include those having a linear structure and those having a branched structure, and a linear alkyl group or a linear alkenyl group is preferred. The double bond in the alkenyl group may be at any arbitrary position.

[0036] Examples of the aliphatic ester having at least one alkyl group or alkenyl group having 6 to 30 carbon atoms in the molecule that is mentioned for the ester-type ashless friction modifier include esters of a fatty acid having an alkyl group or an alkenyl group with 6 to 30 carbon atoms and an aliphatic monoalcohol or an aliphatic polyalcohol, and specifically, preferred examples thereof include glycerin monooleate, glycerin dioleate, sorbitan monooleate, sorbitan dioleate, etc. Containing glycerin monooleate is more preferred, and glycerin monooleate is even more preferred. One alone or two or more different kinds of the above-mentioned ester-type ashless friction modifiers may be used either singly or as combined.

[0037] Examples of the aliphatic amine having at least one alkyl group or alkenyl group with 6 to 30 carbon atoms in the molecule that is mentioned for the amine-type ashless friction modifier include aliphatic monoamines and alkylene oxide adducts thereof, alkanolamines, aliphatic polyamines, imidazoline compounds, etc.

[0038] The aliphatic monoamine for use herein may be an aliphatic monoamine having 6 to 30 carbon atoms, preferably 12 to 24 carbon atoms, more preferably 16 to 22 carbon atoms, and the aliphatic monoamine of the type may be have linear structure or a branched structure, and may be a saturated one or an unsaturated one.

[0039] The alkylene oxide adduct of the aliphatic monoamine is preferably an adduct of an alkylene oxide having 2 or 3 carbon atoms and the aliphatic monoamine. Specific examples of the alkylene oxide adduct of the aliphatic monoamine include various amine-type ashless friction modifiers, for example, monoethanolamine compounds such as hexylmonoethanolamine, heptylmonoethanolamine, octylmonoethanolamine, 2-ethylhexylmonoethanolamine, nonylmonoethanolamine, decylmonoethanolamine, undecylmonoethanolamine, dodecylmonoethanolamine, tridecylmonoethanolamine, tetradecylmonoethanolamine, pentadecylmonoethanolamine, hexadecylmonoethanolamine, heptadecylmonoethanolamine, octadecylmonoethanolamine (stearylmonoethanolamine), 2-heptylundecylmonoethanolamine, nonadecylmonoethanolamine, eicosylmonoethanolamine, heneicosylmonoethanolamine, docosylmonoethanolamine, tricosylmonoethanolamine, tetracosylmonoethanolamine, 11-ethyltricosylmonoethanolamine, pentacosylmonoethanolamine, hexacosylmonoethanolamine, heptacosylmonoethanolamine, octacosylmonoethanolamine, nonacosylmonoethanolamine, triacontylmonoethanolamine, etc.; diethanolamine compounds, monopropylamine compounds and dipropylamine compounds having diethanolamine, monopropylamine or dipropylamine, respectively, in place of the monoethanolamine in the above-mentioned alkylmonoethanolamine compounds; octadecenylmonoethanolamine compounds and octadecenylmonoethanolamine compounds having an alkenyl group in place of the alkyl group in the above-mentioned compounds, etc. Diethanolamine compounds are more preferred.

[0040] In the present invention, among the above-mentioned amine-type ashless friction modifiers, at least one of octadecenylmonoethanolamine and octadecylmonoethanolamine is preferably used, from the viewpoint of the friction-reducing effect thereof.

[0041] One alone or two or more kinds of the above-mentioned amine-type ashless friction modifiers may be used either singly or as combined. In the present invention, the amine-type ashless friction modifier may be used in combination with the above-mentioned ester-type ashless friction modifier.

[0042] The content of the ester-type ashless friction modifier and/or the amine-type ashless friction modifier in the present invention is preferably 0.1% by mass or more and less than 2% by mass based on the total amount of the composition. When the content of the ashless friction modifier is 0.1% by mass or more, in particular, an excellent friction-reducing effect in a sliding mechanism equipped with a piston ring and a liner, especially an excellent friction-modifying effect in a mixed lubrication region can be favorably realized. In turn, even when the content is 2.0% by mass or more, any further improvement of the effect worth the content increase could not be expected. From the above-mentioned viewpoint, the content of the ester-type ashless friction modifier and/or the amine-type ashless friction modifier (2) is more preferably 0.5% by mass or more and 1.5% by mass or less, even more preferably 0.7% by mass or more and 1.3% by mass or less.

((Metallic detergent))

[0043] Preferably, the lubricating oil composition of the present invention contains a metallic detergent. Examples of the metallic detergent include alkali metal (sodium (Na), potassium (K) or the like) or alkaline earth metal (calcium (Ca),

magnesium (Mg), barium (Ba) or the like) sulfonates, phenates, salicylates, naphthenates, etc. In the present invention, an alkaline earth metal, especially calcium (Ca) and/or magnesium (Mg)-containing metallic detergent is preferably used as the metallic detergent, and sulfonates, phenates and salicylates thereof are especially preferably used. One alone or two or more different kinds of these may be used either singly or as combined.

[0044] The metallic detergent may be any of neutral salts, basic salts and overbased salts. The total base number and the content of these metallic detergents may be arbitrarily selected in accordance with the desired performance of the lubricating oil. The total base number is, according to a perchloric acid method, generally 500 mg-KOH/g or less, preferably 20 mg-KOH/g or more and 400 mg-KOH/g or less. The content is generally 0.1% by mass or more and 10% by mass or less based on the total amount of the lubricating oil composition, and is, as a total equivalent of calcium (Ca) and magnesium (Mg), 0.05% by mass or more and 0.3% by mass or less, preferably 0.1% by mass or more and 0.3% by mass or less. When the content of the metallic detergent is too small, the cleanliness would be insufficient; but when too much, the friction coefficient-reducing effect may be insufficient as the case may be.

[0045] The total base number as referred to herein means the total base number measured through potentiometric titration (base number/perchloric acid method) according to 7. of JIS K 2501 "Petroleum Products and Lubricating Oils - Test Method for Neutralization Number".

(Polybutenylsuccinic imide and/or a boronated polybutenylsuccinic imide)

[0046] The lubricating oil composition of the present invention preferably contains polybutenylsuccinic imide and/or a boronated polybutenylsuccinic imide as an ashless dispersant.

[0047] The polybutenylsuccinic imide has a polybutenyl group having a number-average molecular weight of 900 to 3,500, and is generally obtained by reacting a polybutenylsuccinic acid anhydride, which is obtained through reaction of a polybutene and a maleic anhydride, or an alkylsuccinic acid anhydride obtained through hydrogenation thereof, with a polyamine.

[0048] The polyamine includes a simple diamine such as ethylenediamine, propylenediamine, butylenediamine, pentylenediamine, etc.; a polyalkylenepolyamine such as diethylenetriamine, triethylenetetramine, tetraethylenepentamine, pentaethylenehexamine, di(methylethylene)triamine, dibutylenetriamine, tributyltetramine, pentapentylenehexamine, etc.; a piperazine derivative such as aminoethylpiperazine, etc.

[0049] In addition to the above-mentioned polybutenylsuccinic imide, their borides and/or those prepared by modifying them with an organic acid are also usable. The boronated polybutenylsuccinic imide for use herein may be one produced according to an ordinary method. For example, a polybutenylsuccinic acid anhydride is prepared as above, and is then reacted for imidation with an intermediate that is prepared by reacting a polyamine with a boron compound such as boron oxide, boron halide, boric acid, boric anhydride, borate ester, ammonium borate or the like to prepare a boronated polybutenylsuccinic imide.

[0050] One alone or two or more different kinds of polybutenylsuccinic imides and/or boronated polybutenylsuccinic imides may be used either singly or as combined.

[0051] The content of the polybutenylsuccinic imide and/or the boronated polybutenylsuccinic imide is 0.5% by mass or more and 15% by mass or less based on the total amount of the lubricating oil composition, preferably 1% by mass or more and 10% by mass or less. When the amount of the additive falls within the above range, the high-temperature cleanability of the lubricating oil composition sufficiently improves, and the low-temperature flowability thereof also significantly improves. The content of the polybutenylsuccinic imide and/or the boronated polybutenylsuccinic imide is preferably 0.04% by mass or more and 40% by mass or less as a succinimide compound-derived nitrogen content based on the total amount of the lubricating oil composition. Further, in the case where the succinimide compound contains a boride thereof, the boron content derived from the boride is preferably 0.01% by mass or more and 0.3% by mass or less based on the total amount of the composition. When the boron content falls within the range, good cleanability and dispersibility can be realized.

(Other additives)

[0052] The lubricating oil composition of the present invention may further contain, as blended therein, an anti-wear agent, an extreme-pressure agent, an antioxidant, a friction modifier, a pour point depressant, a rust inhibitor, a deactivator, a defoaming agent, etc., in addition to the above-mentioned various additives. Further, in addition to the polymethacrylate or the olefin copolymer having a specific molecular weight and the specific friction modifier in the present invention, the lubricating oil composition may optionally contain any other viscosity index improver, friction modifier, etc.

[0053] The anti-wear agent and the extreme-pressure agent may be suitably selected from any known anti-wear agent and extreme-pressure agent that are heretofore used as an anti-wear agent and an extreme-pressure agent in engine oils. For example, there are mentioned metal (Zn, Pb, Sb, Mo, etc.) dithiophosphates, metal (Zn, Pb, Sb, Mo, etc.) dithiocarbamates, metal (Pb, etc.) naphthenates, metal (Pb, etc.) salts of fatty acids, boron compounds, phosphate

esters, phosphite esters, alkylhydrogen phosphites, phosphate amine salts, phosphate metal salt (Zn, etc.), disulfides, sulfurized oils and fats, sulfurized olefins, dialkyl polysulfides, diarylalkyl polysulfides, diaryl polysulfides, etc. One alone or two or more kinds of these anti-wear agents and extreme-pressure agents may be used either singly or as combined, and in general, the content thereof falls within a range of 0.1% by mass or more and 5% by mass or less based on the total amount of the lubricating oil composition.

[0054] The antioxidant for use herein may be suitably selected from any known antioxidants heretofore generally used as an antioxidant in engine oils. Phenolic antioxidants, amine-type antioxidants, molybdenum-containing antioxidants, sulfur-containing antioxidants, phosphorus-containing antioxidants and the like are preferably used. Concretely, there are mentioned amine-type antioxidants such as alkylated diphenylamines, phenyl- α -naphthylamines, alkylated phenyl- α -naphthylamines, etc.; phenolic antioxidants such as 2,6-di-tert-butylphenol, 4,4'-methylenebis(2,6-di-tert-butylphenol), isooctyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate, octadecyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate, etc.; sulfur-containing antioxidants such as dilauryl-3,3'-thiodipropionate, etc.; phosphorus-containing antioxidants such as phosphite, etc.; and further molybdenum-containing antioxidants. One or more kinds of these antioxidants may be used either singly or as combined, but in general, using two or more is preferred. The content is preferably 0.01% by mass or more and 5% by mass or less based on the total amount of the lubricating oil composition, more preferably 0.2% by mass or more and 3% by mass or less.

[0055] Examples of the friction modifier include organic molybdenum compounds, fatty acids, higher alcohols, oils and fats, amides, sulfurized esters, phosphate esters, phosphite esters, phosphate amine salts, etc. One alone or two or more different kinds of these friction modifiers may be used either singly or as combined in any desired manner, and in general, the content thereof falls within a range of 0.05% by mass or more and 4% by mass or less based on the total amount of the lubricating oil composition.

[0056] Examples of the pour point depressant include ethylene/vinyl acetate copolymers, condensation products of paraffin chloride and naphthalene, condensation products of paraffin chloride and phenol, polymethacrylates, polyalkylstyrenes, etc. The content of the agent generally falls within a range of 0.01% by mass or more and 5% by mass or less based on the total amount of the lubricating oil composition.

[0057] Examples of the rust inhibitor include fatty acids, alkenylsuccinic acid half esters, fatty acid soaps, alkylsulfonate salts, fatty acid amines, paraffin oxides, alkylpolyoxyethylene ethers, etc., and in general, the content thereof is within a range of 0.01% by mass or more and 3% by mass or less based on the lubricating oil composition.

[0058] The metal deactivator includes benzotriazole, triazole derivatives, benzotriazole derivatives, thiadiazole derivatives, etc., and in general, the content thereof is within a range of 0.01% by mass or more and 3% by mass or less based on the total amount of the lubricating oil composition.

[0059] Examples of the defoaming agent include dimethylpolysiloxanes, polyacrylates, etc.

(Lubricating oil composition)

[0060] The lubricating oil composition of the present invention contains the above-mentioned lubricant base oil, the above-mentioned indispensable components, and optionally the above-mentioned various additives.

[0061] In the lubricating oil composition of the present invention, preferably, the phosphorus content is 0.12% by mass or less based on the total amount of the lubricating oil composition. In general, it is often preferable that the phosphorus content in the composition is large in some degree from the viewpoint of wear-resistant properties, etc., but on the other hand, reducing the content of a phosphorus-containing compound is desired from the viewpoint of environmental load reduction. In the present invention, even when the phosphorus content is low, that is, 0.12% by mass or less, the composition can exhibit an excellent friction-reducing effect. From this viewpoint, the phosphorus content is more preferably 0.10% by mass or less based on the total amount of the lubricating oil composition.

[0062] The phosphorus content may be controlled to be the content of the phosphorus-containing additive mentioned above. For example, typical phosphorus-containing anti-wear agents include phosphate esters, thiophosphate esters, especially zinc dithiophosphate (ZnDTP), and use and the content of these additives may be suitably controlled.

[0063] The lubricating oil composition of the present invention has a shear viscosity at 150°C of 2.3 mPa·s or more and 3.7 mPa·s or less. When the shear viscosity at 150°C is lower than 2.3 mPa·s, the friction-reducing effect on a high-temperature side is not sufficient, but when the shear viscosity is higher than 3.7 mPa·s, the friction-reducing effect on a low-temperature side is insufficient on the contrary. From the viewpoint, the shear viscosity of the lubricating oil composition of the present invention at 150°C is preferably 2.5 mPa·s or more and 3.5 mPa·s or less.

[0064] The "shear viscosity at 150°C" in the present invention can be controlled, for example, by controlling the molecular weight and the content of the polymethacrylate and/or the olefin copolymer (1) and other viscosity index improver, etc., and by controlling the viscosity and the like of the base oil. Regarding the measurement method, the viscosity of the composition is measured after shorn at a shearing rate of 10⁶/s at 150°C, according to JPI-5S-36-2003.

[0065] The kinematic viscosity of the lubricating oil composition of the present invention at 40°C is preferably 20 mm²/s to 100 mm²/s, more preferably 30 mm²/s to 80 mm²/s, more preferably 40 mm²/s to 70 mm²/s. Also preferably, the

kinematic viscosity at 100°C is 5 mm²/s to 30 mm²/s, more preferably 5 mm²/s to 20 mm²/s, more preferably 6 mm²/s to 15 mm²/s. When the kinematic viscosity at 40°C or 100°C falls within the above range, an excellent friction-reducing effect can be favorably realized.

[0066] The viscosity index of the lubricating oil composition of the present invention is preferably 120 or more. When the viscosity index is 120 or more, the low-temperature viscosity of the composition can be low to realize fuel saving and the high-temperature viscosity thereof can be high to secure lubricity at a high temperature. From this viewpoint, the viscosity index of the lubricating oil composition of the present invention is preferably 140 or more, more preferably 160 or more, even more preferably 180 or more, still more preferably 200 or more. The kinematic viscosity and the viscosity index can be measured according to JIS K 2283.

(Friction energy of lubricating oil composition)

[0067] In the present invention, the friction energy of the lubricating oil composition can be measured using a floating liner friction tester shown in Fig. 1. The floating liner friction tester shown in Fig. 1 is described below.

[0068] The floating liner friction tester 1 has a block 2 that has a piston movement pathway 2a and crankshaft housing part 2b, a liner 12 arranged along the inner wall of the piston movement pathway 2a, a piston 4 housed in the liner 12, piston rings 6 and 8 outwardly fitted to the piston 4, a crankshaft 10 housed in the crankshaft housing part 2b, a connecting rod 9 connecting the crankshaft 10 and the piston 4, and a load monitoring sensor 14 sandwiched between the liner 12 and the piston movement pathway 2a to monitor the friction force given between the piston rings 6 and 8 and the liner 12 by the piston reciprocating motion of the piston 4.

[0069] The crankshaft 10 is rotationally driven by a motor (not shown) to induce the reciprocating motion of the piston 4 via the connecting rod 9.

[0070] The load monitoring sensor 14 is fixed to the liner 12 via a fixation screw 18. The floating liner friction tester 1 may be provided with a thermometer 16 for measuring the temperature of the liner 12, as shown in Fig. 1.

[0071] In the floating liner friction tester 1, the friction force given between the piston ring 6 and the liner 12 by the movement of the piston 4 is measured by the load monitoring sensor 14.

[0072] In the floating liner friction tester 1 having the constitution as above, a lubricating oil composition 20 is filled in the crankshaft housing part 2b so that the liquid level could be higher than the center of the center axis of the crankshaft 10 and lower than the top end of the center axis. The lubricating oil composition 20 in the crankshaft housing part 2b is fed between the liner 12 and the piston ring 6 by the splash motion of the rotating crankshaft 10.

[0073] The friction energy of the lubricating oil composition of the present invention at a liner temperature of 90°C, as measured using the floating liner friction tester 1 having the specifications mentioned below under the following measurement conditions, is preferably 4.6 J/rotation or less, more preferably 4.4 J/rotation or less, from the viewpoint of reducing the friction in a sliding mechanism.

<Specifications of floating liner friction tester 1>

[0074]

Test apparatus: floating liner friction tester driven by electromotor
Displacement: 315 cm³ (single cylinder)
Ring material: steel (CrN coating for surface treatment)
Liner material: FC250 cast iron

<Measurement conditions for floating liner friction tester 1>

[0075]

Liner temperature: 90°C
Number of rotation: 900 rpm
Measurement item: friction force given to liner part (unit: N)
Evaluation item: friction energy per one rotation calculated from friction force (unit: J/rotation)

[0076] The friction energy of the lubricating oil composition of the present invention, as measured using the floating liner friction tester 1 having the specifications mentioned above and under the same conditions as above except that the liner temperature is changed to 30°C, is preferably 4.3 J/rotation or less, more preferably 4.0 J/rotation or less, even more preferably 3.5 J/rotation or less, from the viewpoint of reducing the friction in a sliding mechanism.

(Production method for lubricating oil composition)

[0077] The lubricating oil composition of the present invention may be produced according to a production method including a step of blending the above-mentioned lubricant base oil with the above-mentioned (1) polymethacrylate and/or olefin copolymer having a mass-average molecular weight of 100,000 to 600,000 and the above-mentioned (2) ester-type ashless friction modifier and/or amine-type ashless friction modifier.

[0078] The details of the indispensable components are as mentioned above. Along with the indispensable components, the above-mentioned optional components may also be blended. Further, the production method of the present invention may include any other step than the above-mentioned step.

(Use in device having sliding mechanism equipped with piston ring and liner)

[0079] The lubricating oil composition of the present invention is, as having the above-mentioned effects and advantages, suitable for lubrication of a sliding mechanism equipped with a piston ring and a liner in a device having such a sliding mechanism equipped with a piston ring and a liner, especially for lubrication of a sliding mechanism equipped with a piston ring and a liner of an internal combustion engine.

[0080] The material of the piston ring and a cylinder liner to which the lubricating oil composition of the present invention is applied is not specifically limited. In general, not only aluminum but also cast iron alloys are employable as the material for a cylinder liner, and as the material for a piston ring, an Si-Cr steel or a martensite stainless steel with 11 to 17 mass% Cr is usable. The piston ring is preferably subjected to surface treatment of chromium plating treatment, chromium nitride treatment, nitriding treatment or a combination of any of these treatments. In the present invention, from the viewpoint of realizing excellent friction reduction, adhesiveness and durability, use of the lubricating oil composition of the present invention in a sliding mechanism equipped with a piston ring and a liner where the piston ring is processed through chromium nitridation treatment is preferred as capable of further increasing the advantageous effects of the present invention.

[0081] From the viewpoint of further enhancing fuel-saving performance, the present invention is favorably applied to a sliding mechanism equipped with a piston ring and a liner of an internal combustion engine of automobiles.

[Lubrication method for device having sliding mechanism equipped with piston ring and liner]

[0082] The present invention also relates to a lubrication method of lubricating a device having a sliding mechanism equipped with a piston ring and a liner, using the lubricating oil composition of the present invention. Specifically, the present invention relates to a lubrication method for a device having a sliding mechanism equipped with a piston ring and a liner, wherein a device having a sliding mechanism equipped with a piston ring and a liner is lubricated with a lubricating oil composition that contains a lubricant base oil, (1) a polymethacrylate and/or an olefin copolymer having a mass-average molecular weight of 100,000 to 600,000, and (2) an ester-type ashless friction modifier and/or an amine-type ashless friction modifier, and has a shear viscosity at 150°C of 2.3 mPa·s or more and less than 3.7 mPa·s. The lubricating oil composition and the sliding mechanism equipped with a piston ring and a liner in the present invention are as described above.

[0083] In the present invention, the lubricating oil composition of the present invention is used as a lubricating oil in a sliding part between a piston ring and a cylinder liner to greatly reduce the friction therein in any condition of fluid lubrication or mixed lubrication, thereby contributing toward improvement of fuel-saving performance in the part.

Examples

[0084] Next, the present invention is described concretely with reference to Examples, but the present invention is not whatsoever restricted by these Examples.

[Evaluation Items, Evaluation Methods]

[0085] The properties of the lubricating oil were determined according to the following methods.

(1) Kinematic viscosity (40°C, 100°C): According to JIS K 2283.

(2) Viscosity index: According to JIS K 2283.

(3) Base number: Potentiometric titration (base number/perchloric acid method) according to 7. of JIS K 2501 "Petroleum Products and Lubricating Oils - Test Method for Neutralization Number".

(4) Phosphorus content: According to JPI-5S-38-92.

(5) Shear viscosity: According to JPI-5S-36-2003, the viscosity was measured after shorn at a shearing rate of 10⁶/s

at 150°C.

(6) Friction amount and friction energy: Using a floating liner friction tester shown in Fig. 1, each lubricant composition was tested for the friction force between the piston ring and the liner under the condition mentioned below, from which the friction energy per one rotation (unit: J/rotation) was calculated.

Test apparatus: floating liner friction tester driven by electromotor (Fig. 1)
Displacement: 315 cm³ (single cylinder)
Ring material: steel (CrN coating for surface treatment)
Liner material: FC250 cast iron

Test condition:

[0086]

Liner temperature: 30°C and 90°C
Number of rotation: 900 rpm
Measurement item: friction force given to liner part (unit: N)
Evaluation item: friction energy per one rotation calculated from friction force (unit: J/rotation)

Examples 1 to 6 and Comparative Examples 1 to 7

[0087] As shown in Table 1, various additives were added to the base oil shown in the same Table to prepare a lubricating oil composition. The resultant lubricating oil composition was tested to measure the properties thereof such as the shear viscosity (150°C), the kinematic viscosity (40°C, 100°C), the viscosity index, etc., and the friction energy in the floating liner friction test was evaluated. The results are shown in Table 1.

Table 1

	Example						Comparative Example						
	1	2	3	4	5	6	1	2	3	4	5	6	7
Base oil								40.00					
Hydrotreated base oil 70N	balance	balance	balance	balance	balance	balance		balance	balance	balance	balance	balance	balance
Hydrotreated base oil 100N													
Hydrotreated base oil 150N							44.00						
Hydrotreated base oil 500N							balance						
PMA1 Mw. 400,000	13.00									18.00	2.10	13.00	13.00
PMA2 Mw. 230,000		8.00	6.20										
PMA3 Mw. 45,000									8.10				
OCP Mw. 500,000				8.30	8.30	4.00							
Zinc di-alkyldithiophosphate A	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

(continued)

Lubricating oil Composition (mass%)	Example						Comparative Example						
	1	2	3	4	5	6	1	2	3	4	5	6	7
Zinc di- alkyldithio- phosphate B	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Antioxidant A	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Antioxidant B	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Metallic de- tergent A	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Metallic de- tergent B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Polybut- enylsuccinbi- simide	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Boronated polybut- enylsuccin- monoimide	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Amine-type friction modifier	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00		
Ester-type friction modifier					1.00								
Ether-type friction modifier													1.00
Other addi- tive	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

(continued)

		Example						Comparative Example						
		1	2	3	4	5	6	1	2	3	4	5	6	7
Properties and Performance of Lubricating oil Composition	Phosphorus content [mass%]	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
	Kinematic viscosity	47.3	48.6	47.1	65.1	65.1	44.2	86.6	26.2	46.0	55.7	29.8	47.4	47.3
	40°C [mm ² /s]													
	100°C [mm ² /s]	11.0	10.7	10.1	11.7	11.7	8.35	11.1	5.39	9.20	13.3	5.95	11.1	11.0
	Viscosity index [-]	234	218	209	177	177	168	115	146	187	248	153	235	234
Friction energy at liner temperature 90°C [J/rotation]	Shear viscosity (150°C) [mPa·s]	3.4	3.4	3.1	3.4	3.4	2.7	3.4	2.0	3.4	4.0	2.2	3.4	3.4
	Friction energy at liner temperature 90°C [J/rotation]	4.6	4.3	4.4	4.3	4.3	4.4	4.2	5.0	4.6	4.0	4.9	5.6	5.5
	Friction energy at liner temperature 30°C [J/rotation]	3.4	4.1	3.9	4.1	4.1	4.0	5.8	4.0	4.4	5.0	3.0	3.4	3.4

[0088] The base oils and the additives used are as follows.

(1) Hydrotreated base oil

70N: kinematic viscosity at 40°C, 12.5 mm²/s; kinematic viscosity at 100°C, 3.1 mm²/s; viscosity index, 109; %CA, 0.0; sulfur content, less than 10 mass ppm.

100N: kinematic viscosity at 40°C, 19.6 mm²/s; kinematic viscosity at 100°C, 4.2 mm²/s; viscosity index, 122; %CA, 0.0; sulfur content, less than 10 mass ppm.

150N: kinematic viscosity at 40°C, 31.0 mm²/s; kinematic viscosity at 100°C, 5.35 mm²/s; viscosity index, 105; %CA, 0.0; sulfur content, less than 10 mass ppm.

500N: kinematic viscosity at 40°C, 90.5 mm²/s; kinematic viscosity at 100°C, 10.9 mm²/s; viscosity index, 107; %CA, 0.0; sulfur content, less than 10 mass ppm.

(2) PMA1: polymethacrylate (mass-average molecular weight, 400,000)

(3) PMA2: polymethacrylate (mass-average molecular weight, 230,000)

(4) PMA3: polymethacrylate (mass-average molecular weight, 45,000)

(5) OCP: olefin copolymer (mass-average molecular weight, 500,000)

(6) Zinc dialkyldithiophosphate A: Zn content, 8.9 mass%; phosphorus content, 7.4 mass%, primary alkyl-type zinc dialkyldithiophosphate

(7) Zinc dialkyldithiophosphate B: Zn content, 9.0 mass%; phosphorus content, 8.2 mass%, secondary alkyl-type zinc dialkyldithiophosphate

(8) Antioxidant A: amine-type antioxidant

(9) Antioxidant B: phenolic antioxidant

(10) Metallic detergent A: overbased calcium salicylate [base number (perchloric acid method) 350 mg KOH/g, calcium content 12.1 mass%]

(11) Metallic detergent B: overbased calcium salicylate [base number (perchloric acid method) 225 mg KOH/g, calcium content 7.8 mass%]

(12) Polybutenylsuccinic bisimide: number-average molecular weight of polybutenyl group, 2000; base number (perchloric acid method), 11.9 mg KOH/g; nitrogen content, 0.99 mass%

(13) Boronated polybutenylsuccinic monoimide: number-average molecular weight of polybutenyl group, 1000; base number (perchloric acid method), 25 mg KOH/g; nitrogen content, 1.23 mass%; boron content, 1.3 mass%

(14) Amine-type friction modifier: octadecyldiethanolamine

(15) Ester-type friction modifier: glycerin monooleate

(16) Ether-type friction modifier: polyglycerin Monooleyl ether

(17) Other additives: pour point depressant, rust inhibitor, defoaming agent, etc.

[0089] The compositions of Examples 1 to 6 that are lubricating oil compositions of the present invention are ones produced by adding an amine-type friction modifier or an ester-type friction modifier to an oil prepared by incorporating a polymethacrylate or an olefin copolymer, whose molecular weight falls within the scope defined in the present invention, in a base oil, and the high-temperature shear viscosity (150°C) thereof is controlled to fall within the scope defined in the present invention. In the floating liner friction test, the friction energy of each of these compositions was low under both conditions of a liner temperature 30°C and a liner temperature 90°C.

[0090] On the other hand, in Comparative Examples 1 and 2, the polymethacrylate and the olefin copolymer were not blended. The friction energy with the composition of Comparative Example 1 was high at a liner temperature 30°C. The viscosity of the composition of Comparative Example 2 was too low, and therefore the friction energy with the composition at a liner temperature 90°C was high. With the composition of Comparative Example 3 where the molecular weight of the polymethacrylate is low and oversteps the scope in the present invention, the friction energy at a liner temperature 30°C was high. In Comparative Examples 4 and 5, the high-temperature shear viscosity (150°C) oversteps the scope defined in the present invention, and therefore, the friction energy at a liner temperature 30°C and 90°C was high. In Comparative Examples 6 and 7, the friction modifier in the present invention was not blended, or the ether-type friction modifier not for use in the present invention was blended, and therefore the friction energy at a liner temperature 90°C was high.

Industrial Applicability

[0091] The lubricating oil composition of the present invention greatly reduces the friction in a sliding mechanism equipped with a piston ring and a liner, and contributes toward environmental load reduction and improvement of fuel-saving performance, and therefore favorably used as a lubricating oil for devices having a sliding mechanism equipped with a piston ring and a liner, especially for internal combustion engines.

Reference Signs List

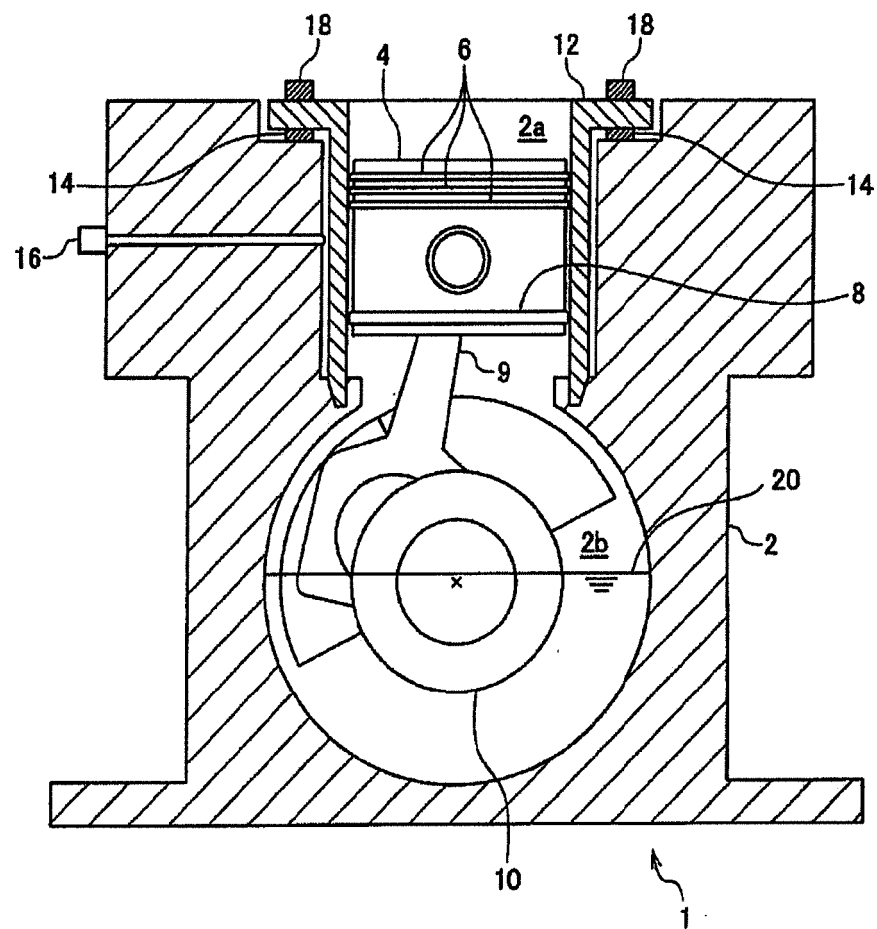
[0092]

- 5 1: Floating Liner Friction Tester
- 2: Block
- 2a: Piston Movement Pathway
- 2b: Crankshaft Housing Part
- 4: Piston
- 10 6, 8: Piston Ring
- 10: Crankshaft
- 12: Liner
- 14: Load Monitoring Sensor
- 16: Thermometer

Claims

- 20 1. A lubricating oil composition for use in a device having a sliding mechanism equipped with a piston ring and a liner, which comprises a lubricant base oil, (1) a polymethacrylate and/or an olefin copolymer having a mass-average molecular weight of 100,000 to 600,000, and (2) an ester-type ashless friction modifier and/or an amine-type ashless friction modifier, and has a shear viscosity at 150°C of 2.3 mPa·s or more and less than 3.7 mPa·s.
- 25 2. The lubricating oil composition according to claim 1, wherein the mass-average molecular weight of the polymethacrylate and/or the olefin copolymer (1) is 200,000 to 550,000.
- 3. The lubricating oil composition according to claim 1 or 2, wherein the content of the polymethacrylate and/or the olefin copolymer (1) is 2.5% by mass or more and less than 15% by mass based on the total amount of the composition.
- 30 4. The lubricating oil composition according to any one of claims 1 to 3, wherein the content of the ashless friction modifier is 0.1% by mass or more and less than 2% by mass based on the total amount of the composition.
- 5. The lubricating oil composition according to any one of claims 1 to 4, wherein the viscosity index of the lubricant base oil is 120 or more.
- 35 6. The lubricating oil composition according to any one of claims 1 to 5, wherein the phosphorus content is 0.12% by mass or less based on the total amount of the composition.
- 7. The lubricating oil composition according to any one of claims 1 to 6, which contains a Ca-containing metallic detergent and/or a Mg-containing metallic detergent in an amount of 0.05% by mass or more and 0.30% by mass or less as a total amount of Ca and Mg based on the total amount of the composition.
- 40 8. The lubricating oil composition according to any one of claims 1 to 7, which comprises polybutenylsuccinic imide and/or a boronated polybutenylsuccinic imide.
- 45 9. The lubricating oil composition according to any one of claims 1 to 8, which is for internal combustion engines.
- 10. The lubricating oil composition according to any one of claims 1 to 9, wherein the piston ring in a sliding mechanism equipped with a piston ring and a liner is one treated with chromium nitride.
- 50 11. A method for producing the lubricating oil composition of any one of claims 1 to 10, which comprises a step of blending a lubricant base oil with (1) a polymethacrylate and/or an olefin copolymer having a mass-average molecular weight of 100,000 to 600,000 stated above and (2) an ester-type ashless friction modifier and/or an amine-type ashless friction modifier stated above.
- 55 12. A method of lubricating a device having a sliding mechanism equipped with a piston ring and a liner, which comprises lubricating a device having a sliding mechanism equipped with a piston ring and a liner with the lubricating oil composition of any one of claims 1 to 10.

Fig. 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/056384

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C10M161/00, C10M129/68, C10M129/95, C10M133/04, C10M133/16, C10M133/56, C10M139/00, C10M143/00, C10M145/14, C10N10/04, C10N20/02, C10N20/04, C10N30/00, C10N30/06, C10N40/02, C10N40/25

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2009/072524 A1 (Nippon Oil Corp.), 11 June 2009 (11.06.2009), claims; paragraphs [0108], [0149], [0193]; examples 1-1 to 3-2 (particularly, examples 2-1 to 2-5) & JP 2009-161612 A & JP 2009-167278 A & JP 2009-155639 A & US 2011/0003725 A1 & EP 2241611 A1 & EP 2474601 A1 & EP 2484746 A1 & CN 101883840 A & CN 103013634 A & CN 103923726 A	1-9, 11-12 1-12

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
14 April 2015 (14.04.15)Date of mailing of the international search report
21 April 2015 (21.04.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/056384

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2010/140562 A1 (Nippon Oil Corp.), 09 December 2010 (09.12.2010), claims; paragraph [0131]; examples 1-1 to 2-6 & JP 2010-280820 A & JP 2010-280823 A & US 2012/0071373 A1 & EP 2439259 A1 & EP 2712911 A2 & CN 102459547 A & CN 103396866 A	1-5, 9, 11-12 1-12
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