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(54) LUBRICANT COMPOSITION AND LUBRICATING METHOD

(57) Provided is a lubricating oil composition containing a refined paraffinic mineral oil (A) and an alkylbenzene (B) having a flash point of 160°C or higher, and having a flash point of 250°C or higher. The lubricating oil composition has a high flash point of 250°C or higher and has an excellent long lifetime to such an extent that the lubricating oil composition can maintain excellent oxidation stability even in long-term use in high-temperature environments.

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Description

Technical Field

[0001] The present invention relates to a lubricating oil composition, and to a lubricating method using the lubricating oil composition.

Background Art

[0002] A lubricating oil composition for use for turbines such as steam turbines, gas turbines, etc., rotary gas compressors, hydraulic machines and the like is used to circulate in a system in high-temperature environments for a long period of time.

[0003] The lubricating oil composition used for a long period of time in high-temperature environments often involves risks of performance degradation owing to oxidation and sludge precipitation owing to oxidation. The precipitated sludge may cause problems of, for example, damage to bearings owing to heat generation after adhesion to rotor bearings, occurrence of clogging of filters arranged in circulation lines, control system operation failure owing to deposition on control valves, etc.

[0004] Consequently, a lubricating oil composition for use for turbines, rotary gas compressors, hydraulic machines and the like is required to have excellent oxidation stability capable of preventing performance degradation and sludge generation owing to oxidation even when used in high-temperature environments for a long period of time.

[0005] For example, PTL 1 discloses a lubricating oil composition containing a refined mineral oil or a synthetic hydrocarbon oil such as a poly-α-olefin or the like as a base oil and containing two kinds of naphthylamine-based antioxidants each having a specific structure in a predetermined ratio.

[0006] PTL 2 discloses a lubricating oil composition containing a lubricant base oil that has an aromatic content ($\%C_A$) of 2 or less, a ratio of a paraffin content (%Cp) to a naphthene content ($\%C_N$) of 6 or more and an iodine value of 2.5 or less, and a sulfur atom-free ash-free antioxidant, and further containing an alkyl group-substituted aromatic hydrocarbon compound such as an alkylnaphthalene or the like.

[0007] PTLs 1 and 2 both intend to provide a lubricating oil composition having oxidation stability and an improved effect of suppression of sludge formation.

Citation List

Patent Literature

[0008] :

PTL 1: JP 7-252489 A
PTL 2: JP 2008-13687 A

Summary of Invention

Technical Problem

[0009] According to the legal stipulation by the Fire Service Act enforced in 2002 in Japan, "a substance that shows liquid at 20°C and at one atmospheric pressure and has a flash point of 200°C or higher and lower than 250°C" is grouped in Group IV hazardous materials in "Class IV petroleums". According to the Fire Service Act, some limitations are imposed on substances that are recognized as "hazardous materials" in point of the storage method or the transportation method, and for handling such a substance in a specific amount or more, a limitation is also imposed to the effect that only a qualified person can handle it.

[0010] Many lubricating oil compositions that are widely distributed for use for turbines, hydraulic machines and the like have a flash point of lower than 250°C, and are therefore grouped in Group IV hazardous materials in "Class IV petroleums", and some limitations are imposed thereon in point of the storage method and the transportation method according to the Fire Service Act.

[0011] On the other hand, according to the Fire Service Act enforced in 2002, "a substance shows liquid at 20°C and at one atmospheric pressure and has a flash point of 250°C or higher (except for gear oil and cylinder oil)" is grouped in "flammable liquids" and are excluded from the designation of hazardous materials. Namely, the limitation on the liquids grouped in "flammable liquids" in point of storage thereof, transportation thereof, handling thereof and the like is relatively loose as compared with the liquids grouped in hazardous materials.

[0012] Consequently, for use for turbines, hydraulic machines and the like, lubricating oil compositions having a flash point of 250°C or higher, which are to be grouped in "flammable liquids" in the Fire Service Act, are required.

[0013] Such high-flash-point lubricating oil compositions are heretofore required in the world from the viewpoint of safety and handleability in storage and transportation.

[0014] Generally, however, many high-flash-point lubricating oil compositions have a high viscosity and, when used in high-temperature environments for a long period of time, those lubricating oil compositions often involve risks of performance degradation or sludge precipitation owing to oxidation and therefore have a problem in point of oxidation stability.

[0015] In PTLs 1 and 2, there is given neither description nor investigation relating to the flash point of lubricating oil compositions, and in these, therefore, there still exist concerns about the stability and the handleability of lubricating oil compositions.

[0016] Further, Examples in PTL 2 disclose an alkylnaphthalene-containing lubricating oil composition. However, the present inventors' investigation has revealed that, in long-term use of an alkylnaphthalene for more than 1,000 hours in high-temperature environments, the naphthalene ring is gradually cleaved to cause reduction in sludge solubility. Consequently, it may be said that the alkylnaphthalene-containing lubricating oil composition causes reduction in oxidation stability in long-term use.

[0017] The present invention has an object of providing a lubricating oil composition having a high flash point of 250°C or higher and having an excellent long lifetime to such an extent that the lubricating oil composition can maintain excellent oxidation stability even in long-term use in high-temperature environments, and providing a lubricating method using the lubricating oil composition.

Solution to Problem

[0018] The present inventors have found that a lubricating oil composition containing an alkylbenzene whose flash point falls within a specific range along with a refined paraffinic mineral oil can solve the above-mentioned problems, and have completed the present invention.

[0019] Specifically, the present invention provides the following [1] and [2].

[1] A lubricating oil composition containing a refined paraffinic mineral oil (A) and an alkylbenzene (B) having a flash point of 160°C or higher, and having a flash point of 250°C or higher.

[2] A lubricating method, which includes using a lubricating oil composition that contains a refined paraffinic mineral oil (A) and an alkylbenzene (B) having a flash point of 160°C or higher, and has a flash point of 250°C or higher.

Advantageous Effects of Invention

[0020] The lubricating oil composition of the present invention has a high flash point of 250°C or higher and has an excellent long lifetime to such an extent that the lubricating oil composition can maintain excellent oxidation stability even in long-term use in high-temperature environments.

Description of Embodiments

[0021] In this description, "flash point" is a value measured according to a Cleveland open-cup method (C.O.C method) according to JIS K2265-4, and "kinematic viscosity" and "viscosity index" each are a value measured according to JIS K2283.

[0022] In this description, the definition of "lubricating oil composition not substantially containing a component X" is to exclude "a lubricating oil composition intentionally mixed with a component X with a specific motivation, and the lubricating oil composition may contain a minor amount of the component X that may be contained therein as an impurity.

[0023] In the lubricating oil composition not substantially containing a component X, the content of the component X that may be contained therein as an impurity is preferably less than 0.01% by mass based on the total amount (100% by mass) of the lubricating oil composition, more preferably less than 0.001% by mass, even more preferably less than 0.0001% by mass, further more preferably less than 0.00001% by mass.

[Lubricating Oil Composition]

[0024] The lubricating oil composition of the present invention contains a refined paraffinic mineral oil (A) and an alkylbenzene (B) having a flash point of 160°C or higher, and has a flash point of 250°C or higher.

[0025] The lubricating oil composition of the present invention contains the component (A) and the component (B) mixed in such a ratio that the flash point thereof is 250°C or higher, and is grouped in "flammable liquids" defined in the

Fire Service Act enforced in 2002 in Japan. Consequently, the lubricating oil composition is excellent in safety and handleability.

[0026] In general, high-flash-point lubricating oil compositions often involve performance degradation and sludge precipitation owing to oxidation in long-term use in high-temperature environments, and have problems in that the oxidation stability thereof is poor and lifetime thereof is short.

[0027] However, the lubricating oil composition of the present invention contains an alkylbenzene (B) having a flash point falling within the above-mentioned range along with a refined paraffinic mineral oil (A), and therefore, while having a flash point of 250°C or higher, the lubricating oil composition can be prevented from oxidation degradation and can dissolve the sludge to form in use and therefore can suppress sludge precipitation, and can contribute toward improvement of oxidation stability.

[0028] Further, the alkylbenzene as the component (B) has high durability even in long-term use in high temperature environments, and can contribute toward prolongation of the lifetime of the lubricating oil composition.

[0029] From the viewpoint of improving anti-foaming performance and vapor releasing performance, preferably, the lubricating oil composition of one aspect of the present invention further contains an anti-foaming agent (C) containing a polyacrylate-based anti-foaming agent (C1).

[0030] From the viewpoint of more improving antioxidation performance, preferably, the lubricating oil composition of one aspect of the present invention further contains an antioxidant (D) containing an amine-based antioxidant (D1).

[0031] Further, the lubricating oil composition of one aspect of the present invention may contain any other base oil and additives for a lubricating oil than the above-mentioned components (A) to (D) within a range not detracting from the advantageous effects of the invention.

[0032] In the lubricating oil composition of one aspect of the present invention, the total content of the component (A) and the component (B) is preferably 60.1% by mass or more based on the total amount (100% by mass) of the lubricating oil composition, more preferably 70% by mass or more, even more preferably 75% by mass or more, further more preferably 80% by mass or more, especially preferably 85% or more, and is generally 100% by mass or less, preferably 95% by mass or less.

[0033] In the lubricating oil composition of one aspect of the present invention, the total content of the component (A), the component (B) and the component (C) is preferably 62% by mass or more based on the total amount (100% by mass) of the lubricating oil composition, more preferably 70% by mass or more, even more preferably 75% by mass or more, further more preferably 80% by mass or more, especially preferably 85% or more, and is generally 100% by mass or less, preferably 95% by mass or less.

[0034] In the lubricating oil composition of one aspect of the present invention, the total content of the component (A), the component (B) and the component (D) is preferably 62% by mass or more based on the total amount (100% by mass) of the lubricating oil composition, more preferably 70% by mass or more, even more preferably 75% by mass or more, further more preferably 80% by mass or more, especially preferably 85% or more, and is generally 100% by mass or less, preferably 95% by mass or less.

[0035] In the lubricating oil composition of one aspect of the present invention, the total content of the component (A), the component (B), the component (C) and the component (D) is preferably 65% by mass or more based on the total amount (100% by mass) of the lubricating oil composition, more preferably 70% by mass or more, even more preferably 75% by mass or more, further more preferably 80% by mass or more, especially preferably 85% or more, and is generally 100% by mass or less, preferably 95% by mass or less.

[0036] In this description, the additives for a lubricating oil such as an anti-foaming agent, a viscosity index improve and others may be blended with the other components in the form of a solution thereof dissolved in a diluent oil selected from a mineral oil, a synthetic oil, a light oil and the like in consideration of the handleability and the solubility thereof in the components (A) and (B). In such a case, in this description, the content of the additive for a lubricating oil such as an anti-foaming agent, a viscosity index improver or the like means the active ingredient-equivalent (resin content-equivalent) content thereof excluding the lubricating oil.

[0037] The components constituting the lubricating oil composition of one aspect of the present invention are described below.

<Refined Paraffinic Mineral Oil (A)>

[0038] The refined paraffinic mineral oil (A) for use in the present invention indicates a paraffinic mineral oil obtained through refining treatment of a lubricant fraction obtained in atmospheric distillation of crude oil.

[0039] Specific examples of the refined paraffinic mineral oil (A) include a paraffinic mineral oil obtained via a refining step of one or more selected from solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, catalytic dewaxing, hydrorefining, sulfuric acid treatment and clay treatment of a lubricant fraction obtained through atmospheric distillation of a crude oil; a paraffinic mineral oil produced according to a process of isomerization of a wax-isomerized mineral oil or a GTL WAX (a gas-to-liquid wax or a Fischer Tropsch wax); etc.

[0040] The refined paraffinic mineral oil (A) for use in the present invention may be used singly or two or more thereof may be used in combination.

[0041] The paraffin content ($\%C_P$) of the refined paraffinic mineral oil (A) is preferably 65 or more, more preferably 70 or more, even more preferably 72 or more, further more preferably 75 or more.

[0042] The naphthene content ($\%C_N$) of the refined paraffinic mineral oil (A) is preferably 35 or less, more preferably 30 or less, even more preferably 28 or less, further more preferably 25 or less.

[0043] The aromatic content ($\%C_A$) of the refined paraffinic mineral oil (A) is preferably less than 2.0, more preferably less than 1.5, even more preferably less than 1.0, further more preferably less than 0.1.

[0044] In this description, the values of $\%C_P$, $\%C_N$ and $\%C_A$ of component (A) are those measured according to the method of ASTM D 3238-85 (n-d-M ring analysis), and each means the "proportion of paraffin carbon number", the "proportion of naphthene carbon number" and the "proportion of aromatic carbon number" relative to the total carbon number (100%) of component (A), respectively.

[0045] The flash point of the refined paraffinic mineral oil (A) is preferably 250°C or higher, more preferably 253°C or higher, even more preferably 255°C or higher, and is preferably 280°C or lower.

[0046] When the flash point of the component (A) is 250°C or higher, the lubricating oil composition whose flash point is 250°C or higher can be produced. In addition, the lubricating oil composition can maintain excellent oxidation stability for a long period of time, and the lifetime thereof can be thereby prolonged.

[0047] When a lubricant fraction obtained through atmospheric distillation of a crude oil is fully refined by combining a plurality of the above-mentioned refining steps, a refined paraffinic mineral oil (A) having a high flash point can be obtained. Namely, with increase in refining frequency, the resultant paraffinic mineral oil may have a higher flash point.

[0048] The kinematic viscosity at 40°C of the refined paraffinic mineral oil (A) is preferably 20 to 300 mm^2/s, more preferably 23 to 200 mm^2/s, even more preferably 25 to 100 mm^2/s.

[0049] The viscosity index of the refined paraffinic mineral oil (A) is preferably 100 or more, more preferably 110 or more, even more preferably 120 or more, further more preferably 130 or more.

[0050] The acid number of the refined paraffinic mineral oil (A) is preferably 0.05 mgKOH/g or less, more preferably 0.03 mgKOH/g or less, even more preferably 0.01 mgKOH/g or less.

[0051] In this description, the acid number means a value measured according to the indicator method of JIS K2501.

[0052] The density at 15°C of the refined paraffinic mineral oil (A) is preferably 0.800 to 0.930 g/cm^3, more preferably 0.810 to 0.900 g/cm^3, even more preferably 0.820 to 0.880 g/cm^3.

[0053] In this description, the density at 15°C means a value measured according to JIS K2249-1.

[0054] The pour point of the refined paraffinic mineral oil (A) is preferably 0°C or lower, more preferably -5°C or lower, even more preferably -10°C or lower, further more preferably -15°C or lower.

[0055] In this description, the pour point means a value measured according to JIS K2269.

[0056] The content of the component (A) in the lubricating oil composition of one aspect of the present invention is, based on the total amount (100% by mass) of the lubricating oil composition, preferably 60 to 99.9% by mass, more preferably 70 to 99.5% by mass, even more preferably 80 to 99.0% by mass, further more preferably 85 to 99.0% by mass.

[0057] When the content of the component (A) is 60% by mass or more, the lubricating oil composition having a flash point of 250°C or higher is easy to prepare. In addition, the lubricating oil composition can maintain excellent oxidation stability for a long period of time, therefore contributing toward prolonging the lifetime thereof.

[0058] On the other hand, when the content of the component (A) is 99.9% by mass or less, the content of the alkylbenzene (B) can be secured and the lubricating oil composition can be prevented from undergoing oxidation degradation and sludge precipitation and can therefore maintain excellent oxidation stability for a long period of time.

<Other Base Oil>

[0059] The lubricating oil composition of one aspect of the present invention may contain any other base oil not corresponding to the component (A). The other base oil may be a mineral oil or a synthetic oil.

[0060] Examples of the mineral oil include an atmospheric residue obtained through atmospheric distillation of a crude oil such as an intermediate mineral oil, a naphthenic mineral oil, etc.; a distillate oil obtained through reduced-pressure distillation of the atmospheric residue; a mineral oil and a wax obtained after one or more refining treatments such as solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, catalytic dewaxing, hydrorefining or the like of the distillate oil; etc. Mineral oils grouped in Group 2 and Group 3 of the API base oil category are preferred; and mineral oils grouped in Group 3 thereof are more preferred. The lubricating oil composition of one aspect of the present invention may contain an unrefined paraffinic mineral oil not corresponding to the component (A).

[0061] Examples of the synthetic oil include poly-α-olefins such as polybutene, α-olefin homopolymers or copolymers (e.g., C_{8-14} α-olefin homopolymers or copolymers such as ethylene-α-olefin copolymers, etc.), etc.; etc.

[0062] In the present invention, "alkylbenzene" belongs to the component (B) to be mentioned below, but not to this category of "synthetic oil".

[0063] In the lubricating oil composition of one aspect of the present invention, the content of the other base oil is, based on the total amount of 100 parts by mass of the component (A), preferably 0 to 30 parts by mass, more preferably 0 to 20 parts by mass, even more preferably 0 to 10 parts by mass, further more preferably 0 to 5 parts by mass.

<Alkylbenzene (B)>

[0064] The alkylbenzene (B) for use in the present invention may be any compound where at least one hydrogen atom of one benzene ring is substituted with an alkyl group.

[0065] The alkylbenzene (B) may be used singly or two or more thereof may be used in combination.

[0066] Examples of the alkyl group that the alkylbenzene (B) has include a methyl group, an ethyl group, various propyl groups, various butyl groups, various pentyl groups, various hexyl groups, various heptyl groups, various octyl groups, various nonyl groups, various decyl groups, various undecyl groups, various dodecyl groups, various tridecyl groups, various tetradecyl groups, various pentadecyl groups, various hexadecyl groups, various heptadecyl groups, various octadecyl groups, various nonadecyl groups, various eicosyl groups, various heneicosyl groups, various docosyl groups, various tricosyl groups, various tetracosyl groups, various pentacosyl groups, various hexacosyl groups, various heptacosyl groups, various octacosyl groups, various nonacosyl groups, various triacontyl groups, various hentriacontyl groups, various dotriacontyl groups, various tritriacontyl groups, various tetratriacontyl groups, various pentatriacontyl groups, various hexatriacontyl groups, various heptatriacontyl group, various octatriacontyl groups, various nonatriacontyl groups, various tetracontyl groups, etc.

[0067] The above-mentioned "various XX groups" include all isomers of the target XX group.

[0068] In the alkylbenzene (B), the number of the alkyl groups substituted on one benzene ring is 1 or more, but is preferably 1 to 4, more preferably 1 to 2.

[0069] In the present invention where the alkylbenzene (B) has plural alkyl groups, the plural alkyl groups may be the same as each other, or may be different from each other.

[0070] The number of the carbon atoms that each alkyl group of the alkylbenzene (B) has is preferably 1 to 40, more preferably 4 to 35, even more preferably 8 to 30.

[0071] The flash point of the alkylbenzene (B) for use in the present invention is 160°C or higher, preferably 170°C or higher, more preferably 175°C or higher, further more preferably 180°C or higher, and even further more preferably 185°C or higher.

[0072] When the flash point of the component (B) is lower than 160°C, the lubricating oil composition having a flash point of 250°C or higher is difficult to prepare. By reducing the content of the component (B), the flash point of the resultant lubricating oil composition may be increased, but the content of the component (B) in the composition is small, and therefore in long-term use thereof, the effect of suppressing the risk of oxidation degradation or sludge precipitation in the lubricating oil composition may be often insufficient.

[0073] The flash point of the alkylbenzene (B) is preferably 250°C lower, more preferably 230°C or lower, even more preferably 220°C or lower, further more preferably 210°C or lower.

[0074] The kinematic viscosity at 40°C of the alkylbenzene (B) is, from the viewpoint of providing a long-life lubricating oil composition capable of maintaining excellent oxidation stability even in long-term use, preferably 45 to 80 mm^2/s, more preferably 47 to 75 mm^2/s, even more preferably 50 to 70 mm^2/s, further more preferably 52 to 65 mm^2/s.

[0075] The kinematic viscosity at 100°C of the alkylbenzene (B) is, from the viewpoint of providing a long-life lubricating oil composition capable of maintaining excellent oxidation stability even in long-term use, preferably 1 to 40 mm^2/s, more preferably 2 to 30 mm^2/s, even more preferably 3 to 20 mm^2/s, further more preferably 4 to 10 mm^2/s.

[0076] The density at 15°C of the alkylbenzene (B) is preferably 0.820 to 0.940 g/cm^3, more preferably 0.835 to 0.920 g/cm^3, even more preferably 0.850 to 0.900 g/cm^3.

[0077] The pour point of the alkylbenzene (B) is preferably -10°C or lower, more preferably -15°C or lower, even more preferably -20°C or lower, further more preferably -30°C or lower.

[0078] In the lubricating oil composition of one aspect of the present invention, the content of the component (B) is, based on the total amount (100% by mass) of the lubricating oil composition, preferably 0.1 to 10% by mass, more preferably 0.15 to 9% by mass, even more preferably 0.2 to 7.5% by mass, further more preferably 0.3 to 6% by mass, especially preferably 0.4 to 5.5% by mass.

[0079] When the content of the component (B) is 0.1% by mass or more, the lubricating oil composition capable of suppressing oxidation degradation and sludge precipitation and capable of maintaining excellent oxidation stability for a long period of time can be obtained.

[0080] On the other hand, when the content of the component (B) is 10% by mass or less, the lubricating oil composition having a flash point of 250°C or higher can be obtained. In the case, in addition, the lubricating oil composition can maintain excellent oxidation stability for a long period of time, and can therefore contribute toward prolonging the lifetime thereof.

[0081] Preferably, the lubricating oil composition of one aspect of the present invention does not substantially contain

an alkylnaphthalene.

[0082] In long-term use in high-temperature environments, the naphthalene ring in an alkylnaphthalene is gradually cleaved to cause reduction in sludge solubility. As a result, in long-term use thereof, the lubricating oil composition containing an alkylnaphthalene tends to undergo oxidation stability degradation and the lifetime thereof tends to be short.

[0083] Consequently, in the lubricating oil composition of one aspect of the present invention, the content of an alkylnaphthalene is preferably as small as possible.

[0084] In the lubricating oil composition of one aspect of the present invention, the content of an alkylnaphthalene is, relative to 100 parts by mass of the total amount of the component (B), preferably 10 parts by mass or less, more preferably 5 parts by mass or less, even more preferably 1 part by mass or less, further more preferably 0.1 parts by mass or less, especially preferably less than 0.01 parts by mass.

<Anti-foaming Agent (C)>

[0085] Preferably, the lubricating oil composition of one aspect of the present invention further contains an anti-foaming agent (C) containing a polyacrylate-based anti-foaming agent (C1) from the viewpoint of improving anti-foaming performance and vapor releasing performance.

[0086] Examples of the polyacrylate-based anti-foaming agent (C1) include a polymethacrylate (PMA) and a modified derivative thereof, etc. A polymethacrylate is preferred.

[0087] The polyacrylate-based anti-foaming agent (C1) may be used singly or two or more thereof may be used in combination.

[0088] The weight average molecular weight (Mw) of the polyacrylate-based anti-foaming agent (C1) is preferably 10,000 to 200,000, more preferably 15,000 to 150,000, even more preferably 20,000 to 100,000.

[0089] In this description, the weight average molecular weight (Mw) is a standard polystyrene-equivalent value measured according to a method of GPC (gel permeation chromatography), and specifically, this is a value measured according to the method described in the section of Examples.

[0090] In one embodiment of the present invention, the composition may contain any other anti-foaming agent than the component (C1) as the anti-foaming agent (C).

[0091] Examples of the other anti-foaming agent than the component (C1) include fatty acid derivatives such as alkenylsuccinic acid derivatives, etc.; alcohols and derivatives thereof such as o-hydroxybenzyl alcohols, etc.; esters of polyhydroxy-aliphatic alcohols and long-chain fatty acids; etc.

[0092] The other anti-foaming agent than the component (C1) may be used singly or two or more thereof may be used in combination.

[0093] The content ratio of the component (C1) in the component (C) is, from the viewpoint of providing the lubricating oil composition having improved anti-foaming performance and vapor releasing performance, preferably 70 to 100% by mass based on the total amount (100% by mass) of the component (C), more preferably 80 to 100% by mass, even more preferably 90 to 100% by mass, further more preferably 95 to 100% by mass.

[0094] Preferably, in the lubricating oil composition of one aspect of the present invention, the component (C) does not substantially contain a silicone-based anti-foaming agent.

[0095] With respect to a lubricating oil composition containing a silicone-based anti-foaming agent, formed foam is difficult to disappear, and therefore, the composition is problematic in point of vapor releasing performance. In addition, since the lubricating oil composition of the type is poor in vapor releasing performance, air is difficult to be removed therefrom, and owing to the presence of air therein, oxidation of the lubricating oil composition proceeds, whereby shortening of the lifetime thereof is likely to be caused.

[0096] Consequently, in the lubricating oil composition of one aspect of the present invention, the content of a silicone-based anti-foaming agent is preferably as small as possible.

[0097] In the lubricating oil composition of one aspect of the present invention, the content of a silicone-based anti-foaming agent is, based on the total amount (100% by mass) of the component (C), preferably 10% by mass or less, more preferably 5% by mass or less, even more preferably 1% by mass or less, further more preferably 0.1% by mass or less, especially preferably less than 0.01% by mass.

[0098] In the lubricating oil composition of one aspect of the present invention, the content of the component (C) is, based on the total amount (100% by mass) of the lubricating oil composition, preferably 0.0001 to 5% by mass, more preferably 0.0002 to 3% by mass, even more preferably 0.0003 to 1% by mass, further more preferably 0.0004 to 0.1% by mass.

[0099] As the case may be, the component (C) may be blended in the form of a solution thereof dissolved in a diluent oil, and regarding the definition thereof, the content of the component (C) means an active ingredient-equivalent (resin content-equivalent) content thereof excluding the diluent oil.

<Antioxidant (D)>

[0100] Preferably, the lubricating oil composition of one aspect of the present invention further contains an antioxidant (D) containing an amine-based antioxidant (D1) from the viewpoint of further improving the antioxidation performance thereof.

[0101] The amine-based antioxidant (D1) may be used singly or two or more thereof may be used in combination.

[0102] The amine-based antioxidant (D1) may be any antioxidant having at least one or more amino groups, and is preferably a monoamine-based antioxidant having one amino group alone.

[0103] The monoamine-based antioxidant is preferably a compound represented by the following general formula (d-1):

$$R^A\text{-NH-}R^B \qquad \text{(d-1)}$$

[0104] In the above-mentioned general formula (d-1), R^A and R^B each independently represent an aryl group having 6 to 18 ring carbon atoms and optionally substituted with an alkyl group having 1 to 20 carbon atoms.

[0105] Examples of the aryl group include a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, an anthryl group, a fluorenyl group, etc. A phenyl group or a naphthyl group is preferred.

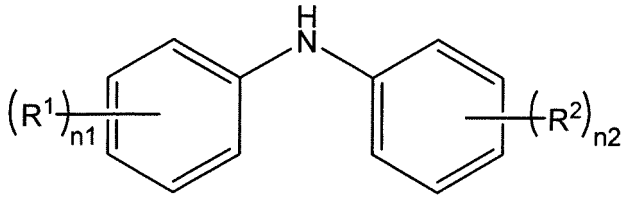
[0106] The alkyl group that may be substituted on the aryl group includes the same ones as the alkyl groups each having 1 to 20 carbon atoms among the alkyl groups that the above-mentioned alkylbenzene (B) may have.

[0107] The carbon number of the alkyl group is preferably 4 to 18, more preferably 6 to 16, even more preferably 8 to 14.

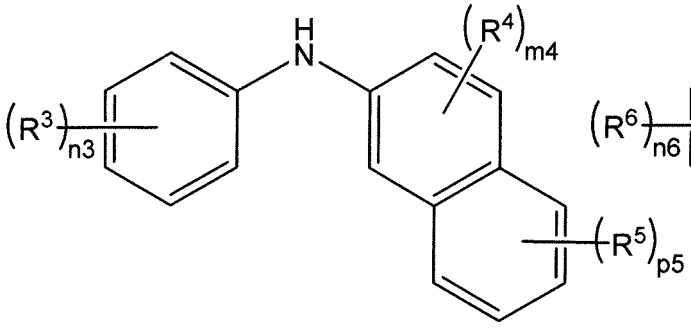
[0108] In one embodiment of the present invention, preferably, the amine-based antioxidant (D1) contains a diphenylamine compound (D11) and a phenyl-naphthylamine compound (D12) from the viewpoint of more improving antioxidation performance. The total content of the component (D11) and the component (D12) in the component (D1) is, based on the total amount (100% by mass) of the component (D1), preferably 70 to 100% by mass, more preferably 80 to 100% by mass, even more preferably 90 to 100% by mass, further more preferably 95 to 100% by mass.

[0109] The diphenylamine compound (D11) is preferably a compound represented by the following general formula (d-11).

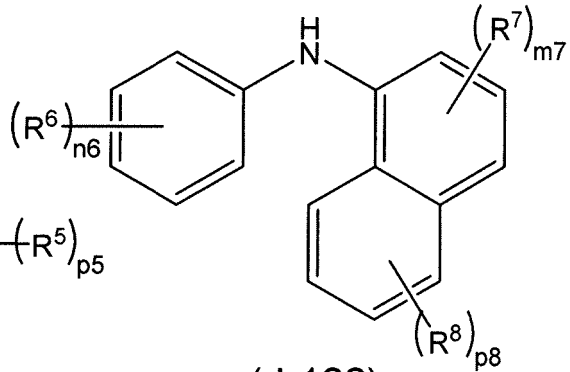
[0110] The phenyl-naphthylamine compound (D12) is preferably one or more selected from a compound represented by the following general formula (d-121) and a compound represented by the following general formula (d-122).



(d-11)



(d-121)



(d-122)

[0111] In the above-mentioned general formulae (d-11), (d-121) and (d-122), R^1 to R^8 each independently represent an alkyl group having 1 to 20 (preferably 4 to 18, more preferably 6 to 16, even more preferably 8 to 14) carbon atoms. The alkyl group includes the same ones as the alkyl group having 1 to 20 carbon atoms among the alkyl groups that the above-mentioned alkylbenzene (B) may have.

n1, n2, n3 and n6 each independently represent an integer of 0 to 5, preferably an integer of 0 to 3, more preferably an integer of 0 to 1, even more preferably 1.

m4 and m7 each independently represent an integer of 0 to 3, preferably an integer of 0 to 1, more preferably 0.

p5 and p8 each independently represent an integer of 0 to 4, preferably an integer of 0 to 2, more preferably an integer of 0 to 1, even more preferably 0.

[0112] The content ratio of the component (D11) to the component (D12) [D11/D12] is, from the viewpoint of more improving antioxidation performance, preferably 0.1/1 to 1/1, more preferably 0.15/1 to 0.85/1, even more preferably 0.2/1 to 0.7/1, further more preferably 0.25/1 to 0.6/1, by mass ratio.

[0113] Preferably, in the lubricating oil composition of one aspect of the present invention, the amine-based antioxidant (D1) does not substantially contain a phenylenediamine compound.

[0114] A lubricating oil composition containing a phenylenediamine compound readily forms sludge in long-term use at a high temperature, and therefore, has a tendency that the sludge formation-preventing effect of the alkylbenzene (B) contained therein is unlikely to be exhibited.

[0115] Consequently, in the lubricating oil composition of one aspect of the present invention, the content of a phenylenediamine compound is preferably as small as possible.

[0116] In the present invention, "phenylenediamine compound" indicates a compound having one benzene ring, in which at least two hydrogen atoms of the benzene ring each are substituted with an amino group, and includes a compound having any other substituent such as an alkyl group or the like than the amino group in the benzene ring.

[0117] In the lubricating oil composition of one aspect of the present invention, the content of the phenylenediamine compound in the component (D1) is, based on the total amount (100% by mass) of the amine-based antioxidant (D1), preferably 10% by mass or less, more preferably 5% by mass or less, even more preferably 1% by mass or less, further more preferably 0.1% by mass or less, especially preferably less than 0.01% by mass.

[0118] In the lubricating oil composition of one aspect of the present invention, the component (D) may contain any other antioxidant than the amine-based antioxidant (D1).

[0119] However, the content ratio of the component (D1) in the component (D) is, based on the total amount (100% by mass) of the component (D) contained in the lubricating oil composition, preferably 50 to 100% by mass, more preferably 60 to 100% by mass, even more preferably 70 to 100% by mass, further more preferably 80 to 100% by mass.

[0120] The other antioxidant than the component (D1) is preferably a phenol-based antioxidant (D2).

[0121] Examples of the phenol-based antioxidant (D2) include monocyclic phenol-based compounds such as 2,6-di-t-butyl-4-methylphenol, 2,6-di-t-butyl-4-ethylphenol, 2,4,6-tri-t-butylphenol, 2,6-di-t-butyl-4-hydroxymethylphenol, 2,6-di-t-butylphenol, 2,4-dimethyl-6-t-butylphenol, 2,6-di-t-butyl-4-(N,N-dimethylaminomethyl)phenol, 2,6-di-t-amyl-4-methylphenol, n-octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate, etc.; and polycyclic phenol-based compounds such as 4,4'-methylenebis(2,6-di-t-butylphenol), 4,4'-isopropylidenebis(2,6-di-t-butylphenol), 2,2'-methylenebis(4-methyl-6-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), 4,4'-butylidenebis(3-methyl-6-t-butylphenol), etc.

[0122] One of these phenol-based antioxidants for (D2) may be used singly or two or more thereof may be used in combination.

[0123] In the case where the amine-based antioxidant (D1) and the phenol-based antioxidant (D2) are used in combination, the content of the phenol-based antioxidant (D2) is, relative to 100 parts by mass of the total amount of the amine-based antioxidant (D1), preferably 0.1 to 100 parts by mass, more preferably 0.5 to 60 parts by mass, even more preferably 1.0 to 40 parts by mass, further more preferably 2.0 to 20 parts by mass.

[0124] In the lubricating oil composition of one aspect of the present invention, the content of the component (D) is, based on the total amount (100% by mass) of the lubricating oil composition, preferably 0.01 to 15% by mass, more preferably 0.05 to 10% by mass, even more preferably 0.10 to 5% by mass, further more preferably 0.20 to 3% by mass.

<Additives for Lubricating Oil>

[0125] The lubricating oil composition of one aspect of the present invention may contain additives for a lubricating oil that may be used in general lubricating oil compositions and do not correspond to the above-mentioned components (A) to (D), within a range not detracting from the advantageous effects of the present invention.

[0126] Examples of such additives for a lubricating oil include a viscosity index improver, a detergent, a dispersant, a metal deactivator, a pour point depressant, an anti-wear agent, a friction regulator, an extreme pressure agent, a rust inhibitor, etc.

[0127] One of these additives may be used singly or two or more thereof may be used in combination.

[0128] In the lubricating oil composition of one aspect of the present invention, the content of each additive for a lubricating oil is, based on the total amount (100% by mass) of the lubricating oil composition, preferably 0.001 to 10% by mass, more preferably 0.005 to 7% by mass, even more preferably 0.01 to 5% by mass, further more preferably 0.05 to 2% by mass.

[Production Method for Lubricating Oil Composition]

[0129] The lubricating oil composition of the present invention may be produced by blending a refined paraffinic mineral oil (A) and an alkylbenzene (B) having a flash point of 160 to 220°C. In this case, as needed, a mineral oil or a synthetic oil, the above-mentioned anti-foaming agent (C) and antioxidant (D) and the above-mentioned additives for a lubricating oil, not corresponding to the components (A) and (B) may be blended along with the components (A) and (B).

[0130] The blending amount of each component is as mentioned above.

[0131] After blended, preferably, the components are stirred and uniformly dispersed according to a known method.

[0132] A lubricating oil composition, in which the constituent components are partly denatured or two components react with each other to form a different component after the components have been blended, also falls within the technical scope of the present invention.

[Various Properties of Lubricating Oil Composition]

[0133] The flash point of the lubricating oil composition of the present invention is 250°C or higher, preferably 253°C or higher, more preferably 255°C or higher, and is preferably 260°C or lower.

[0134] The kinematic viscosity at 40°C of the lubricating oil composition of one aspect of the present invention is preferably 20 to 300 mm^2/s, more preferably 25 to 200 mm^2/s, even more preferably 30 to 100 mm^2/s.

[0135] The viscosity index of the lubricating oil composition of one aspect of the present invention is preferably 115 or more, more preferably 125 or more, even more preferably 135 or more.

[0136] The acid number of the lubricating oil composition of one aspect of the present invention is preferably 1.00 mgKOH/g or less, more preferably 0.50 mgKOH/g or less, even more preferably 0.30 mgKOH/g or less, further more preferably 0.12 mgKOH/g or less.

[0137] The base number of the lubricating oil composition of one aspect of the present invention is preferably 1.00 mgKOH/g or less, more preferably 0.50 mgKOH/g or less, even more preferably 0.30 mgKOH/g or less, further more preferably 0.10 mgKOH/g or less.

[0138] In this description, the base number means a value measured according to the hydrochloric acid method of JIS K2501.

[0139] The density at 15°C of the lubricating oil composition of one aspect of the present invention is preferably 0.800 to 0.930 g/cm^3, more preferably 0.810 to 0.900 g/cm^3, even more preferably 0.820 to 0.880 g/cm^3.

[0140] The pour point of the lubricating oil composition of one aspect of the present invention is preferably 0°C or lower, more preferably -5°C or lower, even more preferably -10°C or lower, further more preferably -15°C or lower.

[0141] When the lubricating oil composition of one aspect of the present invention is tested according to the rotary bomb oxidation test (RBOT) of JIS K 2514-3 at a test temperature of 150°C and under an initial pressure of 620 kPa, the time (RBOT value) taken until the pressure has lowered from the highest pressure by 175 kPa is preferably 1800 minutes or more, more preferably 2000 minutes or more, even more preferably 2200 minutes or more, further more preferably 2400 minutes or more.

[0142] When the lubricating oil composition of one aspect of the present invention is tested according to the oxidation stability test (Dry-TOST method) of ASTM D7873, the time taken until the RPVOT (rotating pressure vessel oxidation test) value thereof according to ASTM D2272 has reached 25% of the RPVOT value before the test is preferably 1400 hours or more, more preferably 1500 hours or more, even more preferably 1600 hours or more, further more preferably 1800 hours or more.

[0143] The sludge formation amount during the time is, when measured through a membrane filter by Merck Millipore Corporation having a mean pore size of 1.0 μm, is preferably 7.0 mg/100 ml or less, more preferably 5.0 mg/100 ml or less, even more preferably 4.0 mg/100 ml or less.

[0144] In a test of the lubricating oil composition of one aspect of the present invention according to ASTM D3427 at a measurement temperature of 50°C, the time taken until the disappearance of foams is preferably shorter than 3.5 minutes, more preferably shorter than 3.0 minutes, even more preferably shorter than 2.5 minutes, and further more preferably shorter than 2.0 minutes.

[0145] In a water release test of the lubricating oil composition of one aspect of the present invention according to JIS K2520 at a temperature of 54°C, the time taken until the emulsified layer has reached 3 mL (demulsification number) is preferably shorter than 10 minutes, more preferably shorter than 8 minutes, even more preferably shorter than 6 minutes.

[Use of Lubricating Oil Composition, and Lubricating Method)

[0146] The lubricating oil composition of one aspect of the present invention can be used as a turbine oil for use for lubrication of various turbines such as steam turbines, nuclear turbines, gas turbines, hydropower turbines, etc.; a bearing oil, a gear oil, or a hydraulic oil for control systems for use for lubrication of various turbomachines such as blowers,

compressors, etc.; and further as a hydraulic fluid, or a lubricating oil for internal combustion engines, etc.

[0147] Namely, the lubricating oil composition of the present invention is favorably used for lubrication of various turbines, various turbomachines, hydraulic machines, etc.

[0148] Consequently, the present invention provides a lubricating method which includes using the above-mentioned lubricating oil composition, that is, "a lubricating method which includes using a lubricating oil composition containing a refined paraffinic mineral oil (A) and an alkylbenzene (B) having a flash point of 160°C to 220°C, and having a flash point of 250°C or higher.

Examples

[0149] Next, the present invention is described further specifically with reference to Examples, but the present invention is not limited to these Examples.

[Method for Measuring Various Physical Data]

(1) Weight Average Molecular Weight (Mw)

[0150] According to a method of GPC (gel permeation chromatography), the measurement was carried out in terms of standard polystyrene. Specifically, the following apparatus was used for the measurement under the following condition.
GPC apparatus: Waters 1515 Isocratic HPLC Pump + Waters 2414 Refractive Index Detector (both by Waters Corporation)

Column: Two columns of "TSKgel Super Multipore HZ-M" (by Tosoh Corporation) were connected.
Column temperature: 40°C
Eluent: tetrahydrofuran
Flow rate: 0.35 mL/min
Detector: refractive index detector

(2) Kinematic Viscosity

[0151] Kinematic viscosity at different temperatures was measured according to JIS K2283.

(3) Viscosity Index

[0152] Measured according to JIS K2283.

(4) Acid Number

[0153] Measured according to the indicator method of JIS K2501.

(5) Base Number (hydrochloric acid method)

[0154] Measured according to the hydrochloric acid method of JIS K2501.

(6) Density (15°C)

[0155] Density at 15°C was measured according to JIS K2249-1.

(7) Flash Point (COC)

[0156] Measured according to a Cleveland open-cup method (C.O.C method) according to JIS K2265-4.

(8) Pour Point

[0157] Measured according to JIS K2269.

(9) $\%C_P$, $\%C_N$, $\%C_A$

[0158] These are values measured according to the method of ASTM D 3238-85 (n-d-M ring analysis), and the proportion (percentage) of the paraffin carbon number is represented by $\%C_P$, the proportion (percentage) of the naphthalene carbon number is represented by $\%C_N$, and the proportion (percentage) of the aromatic carbon number is represented by $\%C_A$.

[0159] Various physical data of the refined paraffinic mineral oils (1) to (3) and the alkylbenzene used in Examples and Comparative Examples, measured according to the above-mentioned methods, are shown in Table 1. The alkylbenzene used in Examples and Comparative Examples, as shown in Table 1, is an alkylbenzene having one alkyl group with 12 to 22 carbon atoms.

Table 1

		Refined Paraffinic Mineral Oil (1)	Refined Paraffinic Mineral Oil (2)	Refined Paraffinic Mineral Oil (3)	Alkylbenzene
Kinematic Viscosity at 40°C	mm^2/s	34.68	20.44	90.51	56.37
Kinematic Viscosity at 100°C	mm^2/s	6.464	4.284	10.89	5.820
Viscosity Index	-	141	116	105	-
Acid Number	mgKOH/g	0.01	0.01	0.01	0.01
Density (15°C)	g/cm3	0.835	0.843	0.871	0.870
Flash Point (COC)	°C	258	212	260	192
Pour Point	°C	-17.5	-20.0	-15.0	-37.5
$\%C_P$	-	82.2	79.1	72.0	-
$\%C_N$	-	17.8	20.9	28.0	-
$\%C_A$	-	0.0	0.0	0.0	-

Examples 1 to 3 and Comparative Examples 1 to 2

[0160] The refined paraffinic mineral oils (1) to (3) and the alkylbenzene having properties shown in Table 1, and various additives for a lubricating oil shown below were blended in the ratio shown in Table 2, and well mixed to produce lubricating oil compositions (I) to (V).

[0161] The details of the additives for a lubricating oil used in Examples and Comparative Examples, as shown in Table 2, are as follows.

(Anti-foaming Agent)

[0162] Polyacrylate-based anti-foaming agent (1): solution having a resin concentration of 1% by mass, prepared by diluting polymethacrylate having Mw of 48000 with light oil.

[0163] Polyacrylate-based anti-foaming agent (2): polymethacrylate having Mw of 51000. Silicone-based anti-foaming agent: solution having a resin concentration of 1% by mass, prepared by diluting polydimethylsilicone having a kinematic viscosity at 25°C of 12500 mm^2/s with light oil.

(Antioxidant)

[0164] Amine-based antioxidant (1): dioctyldiphenylamine (compound of the above general formula (d-11) where R^1 and R^2 are octyl groups, and n1 and n2 are 1), corresponding to the diphenylamine compound (D11).

[0165] Amine-based antioxidant (2): p-t-octylphenyl-1-naphthylamine (compound of the above general formula (d-122) where R^6 is a t-octyl group, n6 is 1, and m7 and p8 are 0), corresponding to the phenyl-naphthylamine compound (D12). Phenol-based antioxidant: diethyl 3,5-di-tert-butyl-4-hydroxybenzylphosphonate.

(Other additives)

[0166]

Extreme pressure agent: tricresyl phosphate
Rust inhibitor: alkenylsuccinic acid polyalcohol ester
Metal deactivator: N-dialkylaminomethylbenzotriazole

[0167] Various physical data indicated in Table 2 of these lubricating oil compositions (I) to (V) were measured according to the above-mentioned methods, and the lubricating oil compositions were tested as shown below to evaluate the oxidation stability, the vapor releasing performance and the water releasing performance thereof. The results are shown in Table 2.

(1) Rotary Bomb Oxidation Test (RBOT)

[0168] According to the rotary bomb oxidation test (RBOT) of JIS K 2514-3 at a test temperature of 150°C and under an initial pressure of 620 kPa, the time (RBOT value, unit: min) taken until the pressure lowered from the highest pressure by 175 kPa was measured. The time is longer, lubricating oil composition can be said to have more excellent oxidation stability.

(2) Oxidation Stability Test (Dry-TOST method)

[0169] According to the oxidation stability test (Dry-TOST method) of ASTM D7873, the time (unit: hr) taken until the RPVOT value according to ASTM D2272 reached 25% of the RPVOT value before the test, and the sludge formation amount during the time (unit: mg/100 ml) were measured.

[0170] The sludge formation amount was measured using a membrane filter by Merck Millipore Corporation having a mean pore size of 1.0 μm according to ASTM D7873.

(3) Vapor Releasing Performance

[0171] According to ASTM D3427, at a measurement temperature of 50°C, the time (unit: min) taken until the disappearance of foams was measured. The time is shorter, lubricating oil composition can be said to have more excellent vapor releasing performance.

(4) Water Releasing Performance

[0172] According to JIS K2520, a water release test at a temperature of 54°C was carried out, and the time taken until the emulsified layer reached 3 mL (demulsification number, unit: min) was measured. The time is shorter, lubricating oil composition can be said to have more excellent water releasing performance.

Table 2

			Example 1	Example 2	Example 3	Comparative Example 1	Comparative Example 2
Lubricating oil Composition			(I)	(II)	(III)	(IV)	(V)
Constituent Components	Refined Paraffinic Mineral Oil (1)	mass%	97.059	98.710	94.009	-	-
	Refined Paraffinic Mineral Oil (2)	mass%	-	-	-	62.11	62.11
	Refined Paraffinic Mineral Oil (3)	mass%	-	-	-	32.00	32.00
	Alkylbenzene	mass%	2.100	0.400	5.000	5.000	5.000
	Polyacrylate-based Anti-foaming Agent (1)	mass%	-	0.050	-	-	0.050
		(resin content)	-	(0.0005)	-	-	(0.0005)
	Polyacrylate-based Anti-foaming Agent (2)	mass%	0.001	-	0.001	-	-
		(resin content)	(0.001)	-	(0.001)	-	-
	Silicone-based Anti-foaming Agent	mass%	-	-	-	0.050	-
		(resin content)	-	-	-	(0.0005)	-
	Amine-based Antioxidant (1)	mass%	0.100	0.100	0.100	0.100	0.100
	Amine-based Antioxidant (2)	mass%	0.250	0.250	0.400	0.250	0.250
	Phenol-based Antioxidant	mass%	0.020	0.020	0.020	0.020	0.020
	Extreme Pressure Agent	mass%	0.400	0.400	0.400	0.400	0.400
	Rust Inhibitor	mass%	0.050	0.050	0.050	0.050	0.050
	Metal Deactivator	mass%	0.020	0.020	0.020	0.020	0.020
	Total	mass%	100.000	100.000	100.000	100.000	100.000
Physical Data	40°C Kinematic Viscosity	mm^2/s	34.48	34.43	34.45	31.49	31.51
	100°C Kinematic Viscosity	mm^2/s	6.395	6.414	6.416	5.662	5.663
	Viscosity Index	-	139	140	140	121	121
	Acid Number (indicator method)	mgKOH/g	0.09	0.09	0.10	0.09	0.09
	Base Number (hydrochloric acid method)	mgKOH/g	0.07	0.07	0.07	0.06	0.06
	Density (15°C)	g/cm^3	0.8369	0.8357	0.8358	0.8491	0.8490
	Flash Point (COC)	°C	255	258	255	246	247
	Pour Point	°C	-17.5	-17.5	-17.5	-17.5	-17.5
Various Test Results	RBOT Value	min	2285	2466	2510	1780	1750
	Dry-TOST: time taken until RPVOT value reached 25% thereof before the test	hr	1640	1800	1950	1300	1300
	Dry-TOST: sludge formation amount at the time when RPVOT value reached 25% thereof before the test	mg/ 100 ml	3.5	3.6	3.5	10.0	10.0
	Vapor Release Test: time until disappearance of foams	min	1.8	1.7	1.8	3.8	2.0
	Water Release Test (54°C): demulsification number	min	5	5	5	10	5

[0173] Regarding the results thereof, the lubricating oil compositions (I) to (III) produced in Examples 1 to 3 have a high flash point of 250°C or higher, and have an excellent long lifetime to such an extent that they can maintain excellent oxidation stability even in long-term use in high-temperature environments. In addition, the lubricating oil compositions (I) to (III) are excellent also in vapor releasing performance and water releasing performance.

[0174] On the other hand, the lubricating oil compositions (IV) and (V) produced in Comparative Examples 1 and 2 have a low flash point of lower than 250°C, and regarding the oxidation stability thereof, they are all inferior to the lubricating oil compositions (I) to (III).

Industrial Applicability

[0175] The lubricating oil composition of the present invention has a high flash point of 250°C or higher and has an excellent long lifetime to such an extent that the lubricating oil composition can maintain excellent oxidation stability even in long-term use in high-temperature environments.

[0176] Consequently, the lubricating oil composition of one aspect of the present invention can be favorably used, for example, for turbine oils, compressor oils, hydraulic oils, etc.

Claims

1. A lubricating oil composition comprising a refined paraffinic mineral oil (A) and an alkylbenzene (B) having a flash point of 160°C or higher, and having a flash point of 250°C or higher.

2. The lubricating oil composition according to claim 1, further comprising an anti-foaming agent (C) containing a polyacrylate-based anti-foaming agent (C1).

3. The lubricating oil composition according to claim 2, wherein the weight average molecular weight of the polyacrylate-based anti-foaming agent (C1) is from 10,000 to 200,000.

4. The lubricating oil composition according to claim 2 or 3, wherein the content of a silicone-based anti-foaming agent based on the total amount of the anti-foaming agent (C) is 10% by mass or less.

5. The lubricating oil composition according to any one of claims 1 to 4, further comprising an antioxidant (D) containing an amine-based antioxidant (D1).

6. The lubricating oil composition according to claim 5, wherein the amine-based antioxidant (D1) contains a diphenylamine compound (D11) and a phenyl-naphthylamine compound (D12).

7. The lubricating oil composition according to claim 6, wherein the content ratio of the component (D11) to the component (D12) [D11/D12] is from 0.1/1 to 1/1 by mass ratio.

8. The lubricating oil composition according to any one of claims 5 to 7, wherein the content of the phenylenediamine-based antioxidant based on the total amount of the amine-based antioxidant (D1) is 10% by mass or less.

9. The lubricating oil composition according to any one of claims 1 to 8, wherein the flash point of the refined paraffinic mineral oil (A) is 250°C or higher.

10. The lubricating oil composition according to any one of claims 1 to 9, wherein the content of the refined paraffinic mineral oil (A) is from 60 to 99.9% by mass, based on the total amount of the lubricating oil composition.

11. The lubricating oil composition according to any one of claims 1 to 10, wherein the kinematic viscosity at 40°C of the refined paraffinic mineral oil (A) is from 20 to 300 mm^2/s.

12. The lubricating oil composition according to any one of claims 1 to 11, wherein the content of the alkylbenzene (B) is from 0.1 to 10% by mass, based on the total amount of the lubricating oil composition.

13. The lubricating oil composition according to any one of claims 1 to 12, wherein the kinematic viscosity at 40°C of the alkylbenzene (B) is from 45 to 80 mm^2/s.

14. The lubricating oil composition according to any one of claims 1 to 13, wherein the content of an alkylnaphthalene is 10 parts by mass or less relative to 100 parts by mass of the total amount of the alkylbenzene (B).

15. A lubricating method, which comprises using a lubricating oil composition which comprises a refined paraffinic mineral oil (A) and an alkylbenzene (B) having a flash point of 160°C or higher, and has a flash point of 250°C or higher.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/077632

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)
C10M169/04, C10M101/02, C10M127/06, C10M133/12, C10M145/14, C10N20/00, C10N20/02, C10N20/04, C10N30/04, C10N30/08, C10N30/10, C10N30/18, C10N40/00, C10N40/02, C10N40/04, C10N40/08, C10N40/12, 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 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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	JP 2009-221330 A (Japan Energy Corp.), 01 October 2009 (01.10.2009), full specification (Family: none)	1-2,5,9-15 3-4,6-8
Y	JP 2008-120996 A (Showa Shell Sekiyu Kabushiki Kaisha), 29 May 2008 (29.05.2008), full specification (Family: none)	3-4
Y	JP 10-219266 A (Tonen Corp.), 18 August 1998 (18.08.1998), full specification & US 6147035 A whole document & EP 860495 A2	6-8

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

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Date of the actual completion of the international search	Date of mailing of the international search report
06 October 2016 (06.10.16)	18 October 2016 (18.10.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/077632

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	JP 49-004107 B1 (Nippon Mining Co., Ltd.), 30 January 1974 (30.01.1974), (Family: none)	1-15
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A	WO 2013/129579 A1 (JX Nippon Oil & Energy Corp.), 06 September 2013 (06.09.2013), & US 2015/0014574 A1 & EP 2821466 A1 & CN 104145008 A & KR 10-2014-0133829 A	1-15
A	JP 51-059781 A (Matsumura Oil Research Corp.), 25 May 1976 (25.05.1976), (Family: none)	1-15

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International application No.
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Continuation of A. CLASSIFICATION OF SUBJECT MATTER
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C10M169/04(2006.01)i, *C10M101/02*(2006.01)n, *C10M127/06*(2006.01)n, *C10M133/12*(2006.01)n, *C10M145/14*(2006.01)n, *C10N20/00*(2006.01)n, *C10N20/02*(2006.01)n, *C10N20/04*(2006.01)n, *C10N30/04*(2006.01)n, *C10N30/08*(2006.01)n, *C10N30/10*(2006.01)n, *C10N30/18*(2006.01)n, *C10N40/00*(2006.01)n, *C10N40/02*(2006.01)n, *C10N40/04*(2006.01)n, *C10N40/08*(2006.01)n, *C10N40/12*(2006.01)n, *C10N40/25*(2006.01)n

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REFERENCES CITED IN THE DESCRIPTION

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