

DESCRIPTION

Title of Invention: GREASE COMPOSITION

Technical Field

[0001] The present invention relates to a grease composition.

5 **Background Art**

[0002] A grease is a semi-solid lubricant prepared by dispersing a fibrous thickener in a base oil, and readily adheres to portions to be lubricated and barely leaks therefrom compared to lubricant oils. For this reason, the grease can simplify the structure of a lubricant system; 10 the grease is used mainly in lubrication of mechanical components such as antifriction bearings, sliding bearings, ball screws, linear guides, and gears, and is widely used in industrial machines and mechanical systems for transportation.

[0003] While a reduction in energy consumption has been demanded 15 recently, a reduction in energy loss of a variety of mechanical systems has been also an urgent problem to be solved. In cases of engine oils for vehicles, it is believed that it is effective to reduce the viscosity of the lubricating base oil as much as possible to ensure low fuel consumption, and to optimize the formulation with a variety of additives 20 such as a friction reducing agent to reduce energy loss due to the viscous resistance of the lubricant oil and reduce the frictional resistance of a sliding portion (Patent Literature 1).

[0004] On the other hand, in the viscous resistance of a grease which is a non-Newtonian fluid, not only the viscosity of the base oil but also an 25 apparent viscosity including the structural viscosity attributed to the fibrous thickener dispersed in the base oil should be considered. The

apparent viscosity can be simply expressed in terms of so-called consistency; it is known that as the consistency is high (soft), the viscous resistance is low (Non Patent Literature 1).

Citation List

5 Patent Literature

[0005] Patent Literature 1: Japanese Unexamined Patent Publication No. 2012-102281

Non Patent Literature

10 [0006] Non Patent Literature 1: Junkatuguriisu no Kiso to Oyou (Basics and Applications of Lubricating Greases), pp. 49 to 89, edited by Grease Working Group, Japanese Society of Tribologists, Yokendo Co., Ltd., 2007

Summary of Invention

Technical Problem

15 [0007] However, it is not always easy for the grease to ensure an appropriate consistency suitable for application to mechanical systems while the viscous resistance is reduced. Namely, if the grease is excessively soft, the grease scatters due to a centrifugal force accompanied by a rotary motion, or leaks from mechanical components.

20 In contrast, if the grease is excessively hard, sliding resistance is generated to obstruct a desired motion. Namely, in cases of conventional greases, an optimal formulation has been carried out only by adjusting a balance between the base oil composition and the amount of the thickener, and any other way has not been found.

25 [0008] The problem to be solved by the present invention is to provide a grease composition which has a low sliding resistance and can

significantly reduce the power consumption of mechanical components, particularly the power consumption during rotation of bearings.

Solution to Problem

[0009] The present inventors, who have conducted extensive research to solve the problem above, have found that a mixture of predetermined amounts of specific base oils having different properties as base oils for a grease can significantly reduce power consumption during rotation of bearings compared to greases in which the base oils are used singly.

[0010] To reduce the energy needed to rotate a bearing to reduce energy consumption, it is important to reduce the rolling resistance and the sliding resistance between a rotational element of a bearing (ball, roller) and bearing rings (inner ring and outer ring) as much as possible; usually, it is believed that a reduction in the viscosity of a base oil for a lubricant oil agent (lubricant oil or grease) and compounding, as an additive, of an oiliness improver having an effect of reducing friction are effective. However, in the case of the grease, a base oil needs to be exposed to a high temperature condition during production of a thickener; therefore, a reduction in viscosity has been limited because of evaporation of the base oil and safety reasons. Furthermore, the additives for reducing friction have a problem in that the effects are reduced with the time of service. In contrast, the present inventors have paid attention to the oil film forming ability of the sliding portion of the bearing and a change in viscosity caused by the temperature of the lubricating base oil, and have found that to form a sufficient oil film between the rotational element of the bearing and the bearing ring to reduce the energy loss caused by direct contact of these components,

containing a component having a molecule having a large steric structure, specifically a component ($\%C_A$ determined by n-d-M ring analysis) containing an aromatic compound in the base oil components, and containing a paraffin component having a high viscosity index ($\%C_P$ determined by n-d-M ring analysis) in a good balance to prevent a reduction in viscosity accompanied by an increase in temperature are effective.

[0011] The present invention has been made based on the above knowledge, and provides a grease composition according to [1] to [9].

[0012] [1] A grease composition comprising: a lubricating base oil; and a thickener, wherein the lubricating base oil comprises a first lubricating base oil having a $\%C_A$ of 2 to 8 and a $\%C_P$ of 50 to 75, the $\%C_A$ and the $\%C_P$ being values determined by n-d-M ring analysis according to ASTM D3238, and a second lubricating base oil having a $\%C_A$ of 1 or less, a $\%C_P$ of 70 or more, and a urea adduct value of 4% by mass or less, the $\%C_A$ and the $\%C_P$ being values determined by n-d-M ring analysis according to ASTM D3238, and wherein a content of the first lubricating base oil is 5 to 90% by mass and a content of the second lubricating base oil is 10 to 95% by mass, based on a total amount of the lubricating base oil.

[2] The grease composition according to [1], wherein the grease composition has a consistency of 220 to 300.

[3] The grease composition according to [1] or [2], further comprising an organomolybdenum compound.

[4] The grease composition according to [3], wherein the organomolybdenum compound comprises at least one selected from

molybdenum dithiocarbamates and molybdenum dithiophosphates.

[5] The grease composition according to any one of [1] to [4], wherein the first lubricating base oil has a kinematic viscosity at 40°C of 10 to 700 mm²/s and a viscosity index of 90 to 120.

5 [6] The grease composition according to any one of [1] to [5], wherein the second lubricating base oil has a kinematic viscosity at 40°C of 10 to 5000 mm²/s and a viscosity index of 110 to 150.

[7] The grease composition according to any one of [1] to [6], wherein the second lubricating base oil comprises at least one selected from mineral oils and synthetic hydrocarbons.

10 [8] The grease composition according to any one of [1] to [7], wherein the thickener comprises at least one selected from metal soap compounds and urea compounds.

[9] A grease composition comprising: a lubricating base oil; a thickener; and an organomolybdenum compound, wherein the lubricating base oil comprises a first lubricating base oil having a %C_A of 2 to 8 and a %C_P of 50 to 75, the %C_A and the %C_P being values determined by n-d-M ring analysis according to ASTM D3238, and a second lubricating base oil having a %C_A of 1 or less and a %C_P of 70 or more, the %C_A and the %C_P being values determined by n-d-M ring analysis according to ASTM D3238, wherein a content of the first lubricating base oil is 5 to 90% by mass and a content of the second lubricating base oil is 10 to 95% by mass, based on a total amount of the lubricating base oil, and wherein the grease composition has a consistency of 220 to 300.

Advantageous Effects of Invention

[0013] The grease composition according to the present invention attains a significant effect that the amount of electric power consumed during rotation of bearings is small.

Description of Embodiments

[0014] Hereinafter, suitable embodiments according to the present invention will be described in detail.

[0015] The grease composition according to an embodiment of the present invention comprises a lubricating base oil and a thickener. The lubricating base oil comprises a first lubricating base oil having a %C_A of 2 to 8 and a %C_P of 50 to 75, which are values determined by n-d-M ring analysis according to ASTM D3238, and a second lubricating base oil having a %C_A of 1 or less and a %C_P of 70 or more, which are values determined by n-d-M ring analysis according to ASTM D3238, and a urea adduct value of 4% by mass or less. In the mixing ratio of the first lubricating base oil to the second lubricating base oil, the content of the first lubricating base oil is 5 to 90% by mass and the content of the second lubricating base oil is 10 to 95% by mass based on the total amount of the lubricating base oil.

[0016] In the present embodiment, the present inventors have paid attention to the oil film forming ability of the sliding portion of the bearing and a change in viscosity caused by the temperature of the lubricating base oil, and has found a knowledge that to form a sufficient oil film between the rotational element of the bearing and the bearing ring to reduce the energy loss caused by direct contact of these components, a "wedge effect" accompanied by rotation of the bearing ring and the rotational element of the bearing is utilized, and containing

a base oil forming molecule having a large steric structure, specifically a component (%C_A determined by n-d-M ring analysis) containing an aromatic in the base oil components is effective; based on this knowledge, the first lubricating base oil is used.

5 [0017] In the values determined by n-d-M ring analysis according to ASTM D3238, the first lubricating base oil has a %C_A of 2 to 8, preferably 2 to 6, more preferably 4 to 6. If the %C_A is less than 2, the effect of reducing energy loss is insufficient, and if the %C_A is more than 8, the content of the paraffin component is readily relatively
10 reduced, resulting in a large reduction in viscosity at high temperatures and thus an insufficient oil film forming ability.

[0018] The first lubricating base oil has a %C_P of 50 to 75, preferably 60 to 70. If the %C_P is less than 50, a reduction in viscosity at high temperatures is large and the oil film forming ability is inferior, and if
15 the %C_P is more than 75, the content of the component containing an aromatic is readily relatively reduced, and the effect of reducing energy loss is insufficient.

[0019] The viscosity index of the first lubricating base oil is preferably 90 to 120, more preferably 95 to 115, still more preferably 100 to 110.
20 If the viscosity index is 90 or more, a reduction in viscosity caused by an increase in temperature can be prevented, further improving the oil film forming ability.

[0020] The kinematic viscosity at 40°C of the first lubricating base oil is not limited in particular; to safely prepare a grease having excellent
25 lubrication properties, the kinematic viscosity at 40°C of the first lubricating base oil is preferably 10 to 700 mm²/s, more preferably 20 to

500 mm²/s, still more preferably 25 to 70 mm²/s.

[0021] The viscosity index and the kinematic viscosity at 40°C in the present invention, respectively, indicate the viscosity index and the kinematic viscosity at 40°C measured according to JIS K2283.

5 [0022] Examples of the first lubricating base oil include lubricant oil fractions prepared by refining through various refining processes distilled oils obtained by distilling crude oil under normal pressure or further distilling crude oil under reduced pressure, and having a %C_A of 2 to 8 and a %C_P of 50 to 75, which are values determined by n-d-M
10 ring analysis according to ASTM D3238. The refining process includes hydrorefining, solvent extraction, and solvent dewaxing, which can be combined in an appropriate order to process the distilled oil to obtain the first lubricating base oil according to the present embodiment. Mixtures of two or more refined oils having different
15 properties obtained by processing different crude oils or distilled oils through a combination of different processes in different orders are also useful. As long as the properties of the resulting first lubricating base oil are adjusted such that the above-mentioned physical properties are satisfied, any first lubricating base oil obtained by any method can be
20 preferably used.

[0023] In the present embodiment, the second lubricating base oil is used based on the present inventors' knowledge that containing linear hydrocarbon components and paraffin components having low coefficients of traction in a base oil is effective in the closest site
25 between the rotational element of the bearing and the bearing ring providing elastohydrodynamic lubrication.

[0024] In contrast, if an amount of the paraffin components is large in the lubricating base oil but the paraffin components do not have an appropriate degree of branching, an increase in viscosity is enhanced in the low temperature range, so that the torque is increased at the start of the bearing at low temperatures to cause practical problems; the present inventors have considered these problems, have conducted further research, and have found that a urea adduct value is effective as an index of the paraffin content causing an increase in torque at the start of the bearing at low temperatures. Moreover, the present inventors have found that if a second lubricating base oil satisfying the specific conditions of the urea adduct value, the $\%C_p$, and the $\%C_A$ is mixed with the first lubricating base oil, the torque of the bearing at temperatures ranging from normal temperature to high temperature can be reduced while a rapid increase in starting torque at low temperatures is prevented.

[0025] In the value determined by n-d-M ring analysis according to ASTM D3238, the $\%C_A$ of the second lubricating base oil is 1 or less, preferably 0.8 or less. If the $\%C_A$ is more than 1, suitable paraffin components having low coefficients of traction cannot be sufficiently fed to the closest site between the rotational element of the bearing and the bearing ring providing elastohydrodynamic lubrication.

[0026] The $\%C_p$ of the second lubricating base oil is 70 or more, preferably 75 or more, more preferably 80 or more. If the $\%C_p$ is less than 70, the effect of reducing the coefficient of traction in the closest site between the rotational element of the bearing and the bearing ring providing elastohydrodynamic lubrication is insufficient.

[0027] The urea adduct value of the second lubricating base oil is 4% by mass or less, preferably 3.5% by mass or less, more preferably 3% by mass or less to prevent an increase in viscosity in the low temperature range and prevent an increase in torque at the start of the bearing at low temperatures. Although the urea adduct value of the second lubricating base oil may be 0% by mass, the urea adduct value of the second lubricating base oil is preferably 0.1% by mass or more, more preferably 0.5% by mass or more because a lubricating base oil having a higher viscosity index can be obtained while an increase in torque at the start of the bearing at low temperatures is sufficiently prevented, the dewaxing conditions are relaxed, and economic efficiency is high.

[0028] The urea adduct value in the present invention is measured by the following method. 100 g of a sample oil (lubricating base oil) weighed is placed in a round-bottomed flask; 200 g of urea, 360 ml of toluene, and 40 ml of methanol are added, and are stirred at room temperature for 6 hours. Thereby, white granular crystals are generated in the reaction solution as a urea adduct product. The reaction solution is filtered with a 1-micron filter to extract the generated white granular crystals; the obtained crystals are washed with 50 ml of toluene 6 times. The recovered white crystals are placed in a flask; 300 ml of pure water and 300 ml of toluene are added, and are stirred at 80°C for 1 hour. The aqueous phase is separated and removed through a separation funnel, and the toluene phase is washed with 300 ml of pure water 3 times. A desiccant (sodium sulfate) is added to the toluene phase to dry the toluene phase; then, toluene is

evaporated. The proportion (mass percentage) of the urea adduct product thus obtained to the sample oil is defined as a urea adduct value.

[0029] In the measurement of the urea adduct value, components among isoparaffins, causing an increase in torque at the start of the bearing at low temperatures, and normal paraffins, if remaining in the lubricating base oil, can be surely and accurately collected as urea adduct products; for this reason, the urea adduct product is advantageous as an index of the proportion of normal paraffins and the specific isoparaffins contained. The present inventors have verified by analysis using GC and NMR that the main components of the urea adduct product are urea adduct products of normal paraffins and isoparaffins having 6 or more carbon atoms from the terminal of the main chain to the branched site.

[0030] The viscosity index of the second lubricating base oil is 110 to 150, preferably 115 to 140, more preferably 125 to 140. If the viscosity index is 110 or more, a reduction in viscosity at high temperatures can be prevented, further improving the oil film forming ability. If the viscosity index is 150 or less, production cost to obtain the lubricating base oil is superior.

[0031] The kinematic viscosity at 40°C of the second lubricating base oil is preferably 10 to 5000 mm²/s, more preferably 20 to 3000 mm²/s, still more preferably 25 to 70 mm²/s. If the kinematic viscosity at 40°C is 10 mm²/s or more, a reduction in flash point can be prevented, and a grease can be safely produced. If the kinematic viscosity at 40°C is 5000 mm²/s or less, an increase in viscous resistance can be prevented, and moreover, energy saving properties are superior.

[0032] It is preferred that the second lubricating base oil be one or more selected from mineral oils and synthetic hydrocarbon oils having the above-mentioned properties. A mixed base oil of a mineral oil and a synthetic hydrocarbon oil can be used as the second lubricating base oil.

5 [0033] Examples of the mineral oils for the second lubricating base oil include lubricant oil fractions prepared by refining through various processes distilled oils obtained by distilling crude oil under normal pressure or further distilling the resulting oil under reduced pressure, and having a %C_A of 1 or less and a %C_P of 75 or more, which are
10 values determined by n-d-M ring analysis according to ASTM D3238, and a urea adduct value of 4% by mass or less. The refining process includes hydrocracking, hydrorefining, solvent extraction, solvent dewaxing, and hydrogenation dewaxing, which can be combined in an appropriate order to process the distilled oil to obtain the second
15 lubricating base oil component according to the present invention. Mixtures of two or more refined oils having different properties obtained by processing different crude oils or distilled oils through a combination of different processes in different orders are also useful. As long as the properties of the resulting second lubricating base oil are
20 adjusted such that the above-mentioned physical properties are satisfied, any second lubricating base oil obtained by any method can be preferably used.

[0034] Examples of the synthetic hydrocarbon oils for the second lubricating base oil include polyolefins, such as poly- α -olefins,
25 polybutene, and copolymers of two or more olefins, alkylbenzene, and alkylnaphthalene having a %C_A of 1 or less and a %C_P of 75 or more,

which are values determined by n-d-M ring analysis according to ASTM D3238, and a urea adduct value of 4% by mass or less. Among these, poly- α -olefins are preferred in view of availability, cost, viscosity properties, oxidation stability, and suitability for system members.

5 Among poly- α -olefins, polymerized products such as 1-dodecene and 1-decene are more preferred in view of cost.

[0035] In the present embodiment, the second lubricating base oil may consist of only one of the mineral oil and the synthetic hydrocarbon oil, or may be a mixture of these oils. Namely, examples of a preferred
10 combination of the first lubricating base oil and the second lubricating base oil include a first lubricating base oil (mineral oil) and a second lubricating base oil (mineral oil), a first lubricating base oil (mineral oil) and a second lubricating base oil (synthetic hydrocarbon oil), or a first lubricating base oil (mineral oil) and a second lubricating base oil
15 (mixed base oil of a mineral oil and a synthetic hydrocarbon). These first lubricating base oils (mineral oils), second lubricating base oils (mineral oils), and second lubricating base oils (synthetic hydrocarbon oils) may be used singly or in combinations of two or more.

[0036] The content of the first lubricating base oil is 5 to 90% by mass, preferably 10 to 80% by mass, more preferably 30 to 60% by mass
20 based on the total amount of the lubricating base oil. The content of the second lubricating base oil is 10 to 95% by mass, preferably 20 to 90% by mass, more preferably 40 to 70% by mass based on the total amount of the lubricating base oil. If the contents of the first and
25 second lubricating base oils are out of these ranges, a desired effect of reducing power consumption may not be attained.

[0037] The content of the lubricating base oil is preferably 70 to 98% by mass, particularly preferably 80 to 97% by mass based on the total amount of the grease composition.

[0038] It is preferred that the thickener have one or more selected from metal soap compounds (also referred to as "metal soap thickeners") and urea compounds (also referred to as "urea thickeners").

[0039] Examples of the metal soap thickeners include simple soaps and complex soaps. The simple soap is a metal soap prepared by saponifying a fatty acid or an oil or fat with an alkali metal hydroxide or an alkaline earth metal hydroxide. The complex soap is prepared by forming a combination of a fatty acid used for a simple soap and an organic acid having a different molecular structure into a composite form. The fatty acid may be a fatty acid derivative having a hydroxy group. The fatty acid may be an aliphatic carboxylic acid such as stearic acid or may be an aromatic carboxylic acid such as terephthalic acid. As the fatty acid, aliphatic mono- or dicarboxylic acids, such as aliphatic carboxylic acids having 6 to 20 carbon atoms are used; particularly aliphatic monocarboxylic acids having 12 to 20 carbon atoms and aliphatic dicarboxylic acids having 6 to 14 carbon atoms are preferably used. As the fatty acid, aliphatic monocarboxylic acids containing one hydroxyl group are preferred. As the organic acid used in combination with the fatty acid in the complex soap, acetic acid, dibasic acid such as azelaic acid or sebacic acid, and benzoic acid are suitable.

[0040] As the metal for the metal soap thickener, alkali metals such as lithium and sodium, alkaline earth metals such as calcium, and

amphoteric metals such as aluminum are used. Among these, alkali metals, particularly lithium is preferably used.

[0041] These metal soap thickeners may be used singly or in combinations of two or more. The content of the metal soap thickener is preferably 2 to 30% by mass, more preferably 3 to 20% by mass, still more preferably 10 to 20% by mass based on the total amount of the grease composition, for example.

[0042] As the urea thickener, for example, diurea compounds obtained by a reaction of diisocyanate and monoamine, and polyurea compounds obtained by a reaction of diisocyanate and monoamine or diamine can be used.

[0043] Examples of the diisocyanate include aliphatic diisocyanates and aromatic diisocyanates. Examples of the aliphatic diisocyanates include diisocyanates having a saturated and/or unsaturated linear, branched, or alicyclic hydrocarbon group. For example, phenylene diisocyanate, tolylene diisocyanate, diphenyl diisocyanate, diphenylmethane diisocyanate, octadecane diisocyanate, decane diisocyanate, and hexane diisocyanate are preferred. Examples of the monoamine include aliphatic monoamines and aromatic monoamines.

Examples of the aliphatic monoamines include monoamines having a saturated and/or unsaturated linear, branched, or alicyclic hydrocarbon group. For example, octylamine, dodecylamine, hexadecylamine, stearylamine, oleylamine, aniline, p-toluidine, and cyclohexylamine are preferred. Examples of the diamine include aliphatic diamines and aromatic diamines. Examples of the aliphatic diamines include diamines having a saturated and/or unsaturated linear, branched, or

an aryl group (including an alkylaryl group) having 6 to 24 carbon atoms, preferably 8 to 15 carbon atoms; and X^1 , X^2 , X^3 , and X^4 may be the same or different, and each represent a sulfur atom or an oxygen atom. The alkyl group here includes a primary alkyl group, a secondary alkyl group, and a tertiary alkyl group. These groups may be linear or branched.

[0048] Preferred examples of the alkyl group include an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, an undecyl group, a dodecyl group, a tridecyl group, a tetradecyl group, a pentadecyl group, a hexadecyl group, a heptadecyl group, and an octadecyl group. These may be a primary alkyl group, a secondary alkyl group, or a tertiary alkyl group, and may be linear or branched. Preferred examples of the (alkyl)aryl group include a phenyl group, a tolyl group, an ethylphenyl group, a propylphenyl group, a butylphenyl group, a pentylphenyl group, a hexylphenyl group, an octylphenyl group, a nonylphenyl group, a decylphenyl group, an undecylphenyl group, and a dodecylphenyl group. The alkyl group in the (alkyl)aryl group may be a primary alkyl group, a secondary alkyl group, or tertiary alkyl group, and may be linear or branched. The (alkyl)aryl group includes all of the substitution isomers different from each other in substitution position of the alkyl group on the aryl group.

[0049] Examples of more preferred molybdenum dithiocarbamate can specifically include molybdenum diethyldithiocarbamate sulfide, molybdenum dipropyldithiocarbamate sulfide, molybdenum dibutyldithiocarbamate sulfide, molybdenum dipentyldithiocarbamate

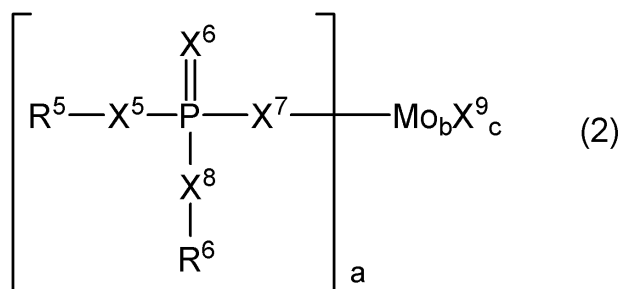
sulfide, molybdenum dihexyldithiocarbamate sulfide, molybdenum dioctyldithiocarbamate sulfide, molybdenum didecyldithiocarbamate sulfide, molybdenum didodecyldithiocarbamate sulfide, molybdenum di(butylphenyl)dithiocarbamate sulfide, molybdenum di(nonylphenyl)dithiocarbamate sulfide, oxymolybdenum diethyldithiocarbamate sulfide, oxymolybdenum dipropyldithiocarbamate sulfide, oxymolybdenum dibutyldithiocarbamate sulfide, oxymolybdenum dipentyldithiocarbamate sulfide, oxymolybdenum dihexyldithiocarbamate sulfide, oxymolybdenum dioctyldithiocarbamate sulfide, oxymolybdenum didecyldithiocarbamate sulfide, oxymolybdenum didodecyldithiocarbamate sulfide, oxymolybdenum di(butylphenyl)dithiocarbamate sulfide, oxymolybdenum di(nonylphenyl)dithiocarbamate sulfide, and mixtures thereof.

The alkyl group in these molybdenum dithiocarbamates may be linear or branched, and in the alkylphenyl group, the attached position of the alkyl group is arbitrary. As these molybdenum dithiocarbamates, compounds having hydrocarbon groups having different carbon atoms and/or structures in one molecule can also be preferably used.

[0050] As molybdenum dithiophosphate, those commercially available as lubricant oil additives can be used; for example, a compound represented by the following formula (2) can be used.

[0051]

[Chemical Formula 2]



[0052] In the formula (2), R^5 and R^6 may be the same or different from each other, and each represent a hydrocarbon group having one or more carbon atoms; X^5 , X^6 , X^7 , X^8 , and X^9 may be the same or different from each other, and each represent an oxygen atom or a sulfur atom; and a, b, and c each represent an integer of 1 to 6; provided that at least one of X^5 , X^6 , X^7 , X^8 , and X^9 represents a sulfur atom. Examples of the hydrocarbon groups represented as R^5 and R^6 include an alkyl group having 1 to 24 carbon atoms, a cycloalkyl group having 5 to 7 carbon atoms, an alkylcycloalkyl group having 6 to 11 carbon atoms, an aryl group having 6 to 18 carbon atoms, an alkylaryl group having 7 to 24 carbon atoms, and an arylalkyl group having 7 to 12 carbon atoms.

[0053] The content of the organomolybdenum compound is preferably 300 mass ppm or more, more preferably 500 mass ppm or more, still more preferably 600 mass ppm or more, particularly preferably 700 mass ppm or more in terms of the amount of the molybdenum element based on the total amount of the grease composition to increase the life of the bearing. The content of the organomolybdenum compound is preferably 50000 mass ppm or less, more preferably 40000 mass ppm or less, still more preferably 30000 mass ppm or less in terms of the amount of the molybdenum element based on the total amount of the grease composition in view of the effect of the added

organomolybdenum compound on the performance of the bearing and production cost. The content of the organomolybdenum compound is preferably 0.1% by mass or more, more preferably 0.5% by mass or more, still more preferably 1% by mass or more in terms of the weight of the molybdenum compound based on the total amount of the grease composition. The content of the organomolybdenum compound is preferably 15% by mass or less, more preferably 10% by mass or less, still more preferably 5% by mass or less in terms of the weight of the molybdenum compound based on the total amount of the grease composition in view of the effect of the added organomolybdenum compound on the performance of the bearing and production cost.

[0054] The grease composition can contain additives usually used in lubricant oils and greases in addition to the components above when necessary. Examples of the additives include detergents, dispersants, wear preventing agents, viscosity index improvers, antioxidants, extreme-pressure agents, rust inhibitors, corrosion inhibitors, metal deactivators, and solid lubricants. The content of these additives is preferably 10% by mass or less, more preferably 5% by mass or less based on the total amount of the grease composition.

[0055] The consistency of the grease composition is preferably 220 to 300, more preferably 225 to 295, still more preferably 230 to 290, particularly preferably 230 to 285. If the consistency is the grease composition within this range, the amount of electric power consumed during rotation of bearings can be significantly reduced. Examples of the method of adjusting the consistency of the grease composition include a method of adjusting the types and the mixing proportion of the

above-described first lubricating base oil, second lubricating base oil, and thickener, and a method of mixing the respective components during production of the grease composition described later (such as the number of mixing operations, the heating temperature, the cooling rate, and the roll condition).

[0056] The consistency in the present invention indicates the worked penetration measured according to JIS K2220. The specific measurement conditions are as follows. A sample is placed in a pot for measuring a consistency, and the pot is kept at 25°C; then, the sample is mixed with 60 reciprocating motions of a specified mixer for 1 minute. Next, an excess sample is removed with a spatula to smooth the surface of the sample, and a specified cone is dropped into the sample for 5 seconds; the value obtained by multiply the depth (mm) of the cone entering the sample by 10 is defined as the worked penetration.

[0057] Another embodiment according to the present invention is a grease composition comprising a lubricating base oil, a thickener, and an organomolybdenum compound, wherein the lubricating base oil comprises a first lubricating base oil having a %C_A of 2 to 8 and a %C_P of 50 to 75, which are values determined by n-d-M ring analysis according to ASTM D3238, and a second lubricating base oil having a %C_A of 1 or less and a %C_P of 70 or more, which are values determined by n-d-M ring analysis according to ASTM D3238, the content of the first lubricating base oil is 5 to 90% by mass and the content of the second lubricating base oil is 10 to 95% by mass based on the total amount of the lubricating base oil, and the consistency is 220 to 300. This embodiment attains significant effects, i.e., compatibility

between a reduction in power consumption during rotation of bearings and an increase in life of bearings.

[0058] The method of producing the grease composition according to the present embodiment comprises a step of mixing a first lubricating base oil, a second lubricating base oil, and a thickener to obtain a grease composition. The first lubricating base oil is mixed with the second lubricating base oil such that the content of the first lubricating base oil is 5 to 90% by mass and the content of the second lubricating base oil is 10 to 95% by mass based on the total amount of the lubricating base oil.

[0059] In the present embodiment, a thickener preliminarily prepared may be mixed with the first and second lubricating base oils, or raw materials for the thickener may be compounded with the first lubricating base oil, the second lubricating base oil, or a mixed base oil thereof, and the raw materials may be reacted in the base oil to obtain a thickener.

For example, if a metal soap thickener is used, the metal soap thickener may be compounded with the lubricating base oil in the form of a metal soap; or a carboxylic acid and a metal source (such as a metal salt or a metal salt hydroxide) may be separately compounded with the lubricating base oil, and the carboxylic acid may be reacted with the metal source during production of the grease to prepare a metal soap thickener. If a urea thickener is used, the urea thickener in the form of a urea compound may be compounded with the lubricating base oil; or a diisocyanate and an amine (such as a monoamine or a diamine) may be compounded with the lubricating base oil, and the diisocyanate may be reacted with the amine during production of the grease to prepare a urea thickener.

[0060] The grease composition obtained by mixing the first lubricating base oil, the second lubricating base oil, and the thickener can be dispersed with a roll or a mill when necessary.

Examples

5 [0061] Hereinafter, the present invention will be described more specifically based on Examples, but the present invention will not be limited to the Examples below.

[0062] [Base oil A]

10 A lubricating base oil having the following properties and obtained by solvent refining a distilled oil obtained by distillation under reduced pressure of a residue of distillation under normal pressure was used as base oil A.

Kinematic viscosity at 40°C: 37.6 mm²/s

Viscosity index: 107

15 Flash point: 220°C

%C_p: 66

%C_A: 5.2

[0063] [Base oil B]

20 A bottom fraction obtained from a fuel oil hydrocracker was used as a raw material for a lubricating base oil, and hydroprocessing was performed with a hydroprocessing catalyst. At this time, the reaction temperature and the liquid hourly space velocity were adjusted such that the cracking rate of normal paraffin in the raw material oils was 10% by mass or less. Furthermore, the processed product
25 obtained by hydroprocessing was subjected to hydrogenation dewaxing in the temperature range of 315 to 325°C with a zeolite hydrogenation

dewaxing catalyst having a noble metal whose content was adjusted to 0.1 to 5% by mass; thereby, a dewaxed oil was obtained. Furthermore, the dewaxed oil was hydrotreated with a hydrotreating catalyst. Subsequently, a lubricating base oil having the following properties and obtained by distillation was used as base oil B.

Kinematic viscosity at 40°C: 36.8 mm²/s

Viscosity index: 130

Flash point: 240°C

%C_P: 79

%C_A: 0

Urea adduct value: 2% by mass

[0064] [Base oil C]

A synthetic hydrocarbon having the following properties, i.e., poly- α -olefin (Durasyn 166 manufactured by INEOS Group AG) was used as base oil C.

Kinematic viscosity at 40°C: 30.8 mm²/s

Viscosity index: 135

Flash point: 250°C

%C_P: 91

%C_A: 0

Urea adduct value: 0% by mass

[0065] [Base oil D]

A fraction separated through distillation under reduced pressure of a solvent refined base oil was solvent extracted with furfural, was then hydroprocessed, and was solvent dewaxed with a mixed solvent of methyl ethyl ketone and toluene. The wax content removed during

solvent dewaxing and obtained as a slack wax was used as a raw material for a lubricating base oil, and hydroprocessing was performed. At this time, the reaction temperature and the liquid hourly space velocity were adjusted, the temperature condition on hydrogenation dewaxing of the processed product obtained by hydroprocessing was adjusted to a low temperature of about 300°C, and the dewaxed oil obtained was hydrotreated. Subsequently, a lubricating base oil having the following properties and a urea adduct value of 5% by mass, and obtained by distillation was used as base oil D.

Kinematic viscosity at 40°C: 32.0 mm²/s

Viscosity index: 130

Flash point: 240°C

%C_p: 75

%C_A: 0

Urea adduct value: 5% by mass

[0066] [Test oils 1-1 to 1-10]

Base oils A, B, C, and D were placed in a stainless steel container in amounts to be compounded shown in Tables 1 and 2 (expressed by % by mass). When a urea compound was used as the thickener, raw materials for the urea compound, i.e., an amine and an isocyanate were added to the lubricating base oil in the container, were heated to 150°C, and were stirred with a magnetic stirrer to react the amine and the diisocyanate. After drying, the reaction product was cooled to room temperature to obtain a semi-solid composition. When a metal soap compound was used as the thickener, lithium stearate was added to the lubricating base oil, was heated to 200°C, and then was

cooled to obtain a semi-solid composition. Furthermore, a phenol antioxidant di-t-butyl-p-cresol was added to each of the resulting semi-solid compositions, and was dispersed with a triple roll mill to obtain grease compositions having the compositions shown in Tables 1 and 2.

[0067] [Evaluation test 1]

The amount of electric power consumed during rotation of a bearing in use of each grease composition was measured by the following method. As the bearing, a double-row tapered roller bearing 4T-CRI-0868 manufactured by NTN Corporation was used. The inside of the bearing was sufficiently washed with an organic solvent before the test, and an experiment oil agent (grease composition) was then injected into gaps between a roller, a bearing ring, and a retainer of the bearing with a syringe. In the experiment, 4 bearings in total (2 bearings $\times$ 2 pairs) filled with the same oil agent were used. The inner ring of the bearing was fixed, and the bearing was rotated through a pulley with an electric motor (manufactured by YASKAWA Electric Corporation, TYPE: FEQ, 2.2 kW) in a certain direction to measure the amount of the power consumption of the electric motor with an electric power meter (manufactured by HIOKI E.E. CORPORATION, CE3169, CLAMP ON POWER HiTESTER). The number of rotations of the bearing was 1300 rpm, the temperature was room temperature, and the integrated power consumption (kW) during continuous rotation for 2 hours was compared. The number of repetitions of the experiment was 3 times. The obtained results are shown in Tables 1 and 2. The power consumption and the electric power reduction rate (%: relative to

Test oil 1-6) of the bearing in Tables 1 and 2 are the average values of the three experiments. In the electric power reduction rate in the present Examples, cases where the power consumption is lower than the reference are shown by negative numeric values.

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[0068] [Table 1]

			Test oil 1-1	Test oil 1-2	Test oil 1-3	Test oil 1-4	Test oil 1-5
Composition (% by mass)	Lubricating base oil (based on total amount of lubricating base oil)	Base oil A	50	40	50	40	50
		Base oil B	50	30	-	30	-
		Base oil C	-	30	50	30	50
		Base oil D	-	-	-	-	-
	Grease composition (based on total amount of grease composition)	Lubricating base oil	84	84	84	84	84
		Thickener (urea)	15	15	15	-	-
		Thickener (metal soap)	-	-	-	15	15
		Additive (phenol antioxidant)	1	1	1	1	1
Consistency of grease composition		285	290	290	290	280	
Evaluation test 1	Power consumption of bearing [Wh]	725	725	724	728	726	
	Electric power reduction rate [%]	-5.60	-5.60	-5.7	-5.2	-5.5	

[0069] [Table 2]

			Test oil 1-6	Test oil 1-7	Test oil 1-8	Test oil 1-9	Test oil 1-10
Composition (% by mass)	Lubricating base oil (based on total amount of lubricating base oil)	Base oil A	100	-	-	50	50
		Base oil B	-	100	-	-	-
		Base oil C	-	-	100	-	-
		Base oil D	-	-	-	50	50
	Grease composition (based on total amount of grease composition)	Lubricating base oil	84	84	84	84	84
		Thickener (urea)	15	15	15	15	-
		Thickener (metal soap)	-	-	-	-	15
		Additive (phenol antioxidant)	1	1	1	1	1
Consistency of grease composition		290	285	290	280	290	
Evaluation test 1		Power consumption of bearing [Wh]	768	772	760	770	774
		Electric power reduction rate [%]	Reference	+0.52	-1.04	+0.26	+0.78

[0070] [Test oils 2-1 to 2-12]

Base oils A, B, C, and D, and the thickener were placed in a stainless steel container in amounts to be compounded (expressed by % by mass) shown in Tables 3 to 5. When a metal soap compound (simple soap) was used as the thickener, lithium stearate was added to the lubricating base oil, and was heated to 200°C; the resultant was then cooled to obtain a semi-solid composition. When a metal soap compound (complex soap) was used as the thickener, 12-hydroxystearic acid, azelaic acid, and lithium hydroxide were added to the lubricating base oil, were heated to 200°C, and were reacted to form a complex soap, which was cooled to obtain a semi-solid composition. When a urea compound was used as the thickener, raw materials for the urea

compound, i.e., an amine and an isocyanate were added to the lubricating base oil in the container, were heated to 150°C, and were stirred with a magnetic stirrer to react the amine and the diisocyanate. After drying, the reaction product was cooled to room temperature to obtain a semi-solid composition. Furthermore, a phenol antioxidant di-t-butyl-p-cresol was added to each of the resulting semi-solid compositions, and was dispersed with a triple roll mill to obtain grease compositions having the compositions shown in Tables 3 to 5. In the resulting grease compositions, the consistency (worked penetration) was measured according to JIS K2220.

[0071] [Evaluation test 2-1]

The amount of electric power consumed during rotation of a bearing in use of each grease composition was measured by the following method. As the bearing, a double-row ball bearing 7008A-DF manufactured by NSK Ltd. was used. The inside of the bearing was sufficiently washed with an organic solvent before the test, an experiment oil agent (grease composition) was injected into gaps between balls, a bearing ring, and a retainer of the bearing with a syringe. In the experiment, 4 bearings in total (2 bearings × 2 pairs) filled with the same oil agent were used. The inner ring of the bearing was fixed, and the bearing was rotated through a pulley with an electric motor (manufactured by YASKAWA Electric Corporation, TYPE: FEQ, 2.2 kW) in a certain direction to measure the amount of the power consumption of the electric motor with an electric power meter (manufactured by HIOKI E.E. CORPORATION, CE3169, CLAMP ON POWER HiTESTER). The number of rotations of the bearing was

1300 rpm, the temperature was room temperature, and the integrated power consumption (kW) during continuous rotation for 2 hours was compared. The number of repetitions of the experiment was 3 times. The obtained results are shown in Tables 3 to 5. The power consumption and the electric power reduction rate (%: relative to test oil 2-11) of the bearing in Tables 3 to 5 are the average values of the three experiments.

[0072] [Evaluation test 2-2]

Each of the grease compositions was subjected to the same test as that in Evaluation test 1. The obtained results are shown in Tables 3 to 5. The power consumption and the electric power reduction rate (%: relative to test oil 2-11) of the bearing in Tables 3 to 5 are the average values of the three experiments.

[0073] [Table 3]

			Test oil 2-1	Test oil 2-2	Test oil 2-3	Test oil 2-4
Composition (% by mass)	Lubricating base oil (based on total amount of lubricating base oil)	Base oil A	60	30	60	60
		Base oil B	40	30	40	40
		Base oil C	-	40	-	-
		Base oil D	-	-	-	-
	Grease composition (based on total amount of grease composition)	Lubricating base oil	88.0	88.0	81.0	83.0
		Thickener (simple soap)	11.0	11.0	-	-
		Thickener (complex soap)	-	-	18.0	16.0
		Thickener (urea)	-	-	-	-
		Additive (phenol antioxidant)	1.0	1.0	1.0	1.0
Consistency of grease composition		250	250	228	255	
Evaluation test 2-1	Power consumption of bearing (Wh)	511	500	498	481	
	Electric power reduction rate (%)	-2.7	-4.8	-5.1	-8.4	
Evaluation test 2-2	Power consumption of bearing (Wh)	-	732	-	736	
	Electric power reduction rate (%)	-	-4.7	-	-4.2	

[0074] [Table 4]

			Test oil 2-5	Test oil 2-6	Test oil 2-7	Test oil 2-8
Composition (% by mass)	Lubricating base oil (based on total amount of lubricating base oil)	Base oil A	60	60	100	60
		Base oil B	40	40	-	40
		Base oil C	-	-	-	-
		Base oil D	-	-	-	-
	Grease composition (based on total amount of grease composition)	Lubricating base oil	85.0	81.0	87.0	90.0
		Thickener (simple soap)	-	-	12.0	9.0
		Thickener (complex soap)	14.0	-	-	-
		Thickener (urea)	-	18.0	-	-
		Additive (phenol antioxidant)	1.0	1.0	1.0	1.0
Consistency of grease composition		282	264	280	310	
Evaluation test 2-1	Power consumption (Wh) of bearing	491	507	540	535	
	Electric power reduction rate (%)	-6.5	-3.4	+2.9	+1.9	
Evaluation test 2-2	Power consumption (Wh) of bearing	-	739	800	784	
	Electric power reduction rate (%)	-	-3.8	+4.2	+2.1	

[0075] [Table 5]

			Test oil 2-9	Test oil 2-10	Test oil 2-11	Test oil 2-12
Composition (% by mass)	Lubricating base oil (based on total amount of lubricating base oil)	Base oil A	60	60	100	60
		Base oil B	40	40	-	-
		Base oil C	-	-	-	-
		Base oil D	-	-	-	40
	Grease composition (based on total amount of grease composition)	Lubricating base oil	86.0	80.0	84.0	84.0
		Thickener (simple soap)	-	-	-	-
		Thickener (complex soap)	13.0	19.0	-	-
		Thickener (urea)	-	-	15.0	15.0
		Additive (phenol antioxidant)	1.0	1.0	1.0	1.0
	Consistency of grease composition		306	210	290	280
Evaluation test 2-1		Power consumption (Wh) of bearing	527	547	525	550
		Electric power reduction rate (%)	+0.4	+4.2	Refer- ence	+4.8
Evaluation test 2-2		Power consumption (Wh) of bearing	776	825	768	770
		Electric power reduction rate (%)	+1.0	+7.4	Refer- ence	+0.3

[0076] [Test oils 3-1 to 3-8]

Base oils A and B, the thickener, and organomolybdenum compounds molybdenum dithiocarbamate (molybdenum element content of 29% by mass, sulfur element content of 28% by mass) and molybdenum dithiophosphate (molybdenum element content of 8% by mass, phosphor element content of 6% by mass, sulfur element content of 12% by mass) were placed in a stainless steel container in amounts to be compounded shown in Tables 6 and 7 (expressed by % by mass. Also the values in terms of the molybdenum element are shown). When a metal soap compound (simple soap) was used as the thickener,

lithium stearate was added to the lubricating base oil, and heated to 200°C; the resultant mixture was then cooled to obtain a semi-solid composition. When a metal soap compound (complex soap) was used as the thickener, 12-hydroxystearic acid, azelaic acid, and lithium hydroxide were added to the lubricating base oil, heated to 200°C, and reacted to form a complex soap, and the resulting mixture was cooled to obtain a semi-solid composition. When a urea compound was used as the thickener, raw materials for the urea compound, i.e., an amine and an isocyanate were added to the lubricating base oil in the container, heated to 150°C, and stirred with a magnetic stirrer to react the amine and the diisocyanate. After drying, the resulting mixture was cooled to room temperature to obtain a semi-solid composition. Furthermore, other additives (such as a phenol antioxidant and a corrosion inhibitor) were added to each of the resulting semi-solid compositions, and were dispersed with a triple roll mill to obtain grease compositions having the compositions shown in Tables 6 and 7. For the resulting grease compositions, the consistency (worked penetration) was measured according to JIS K2220.

[0077] [Evaluation test 3-1 (life of bearing)]

The grease compositions were each subjected to a high temperature grease bearing life test. Specifically, according to ASTM-D3336, 2 g of a sample grease was filled into a bearing (6204ZZ), the bearing was continuously operated at a temperature of 150°C, the number of rotations of 10000 rpm, and a thrust load of 66 N, and the time until abnormal operation was caused accompanied by lubrication failure was recorded as the life (hr) of the bearing.

[0078] [Evaluation test 3-2 (power consumption of bearing)]

The grease compositions were each subjected to the same test as in Evaluation test 2-1. The obtained results are shown in Tables 6 and 7. The power consumption and the electric power reduction rate (%: relative to test oil 3-7) of the bearing in Tables 6 and 7 are the average values of the three experiments.

5

[0079] [Table 6]

			Test oil 3-1	Test oil 3-2	Test oil 3-3	Test oil 3-4
Composition (% by mass)	Lubricating base oil (based on total amount of lubricating base oil)	Base oil A	60	60	60	60
		Base oil B	40	40	40	40
	Grease composition (based on total amount of grease composition)	Lubricating base oil	87	82	80	78
		Thickener (simple soap)	11	-	-	-
		Thickener (complex soap)	-	16	-	16
		Thickener (urea)	-	-	18	-
		Molybdenum dithiocarbamate (in terms of amount of molybdenum element, mass ppm)	1 (2900)	1 (2900)	1 (2900)	5 (14500)
		Molybdenum dithiophosphate (in terms of amount of molybdenum element, mass ppm)	-	-	-	-
	Other additives	1	1	1	1	
Consistency of grease composition		250	255	250	248	
Evaluation test 3-1	Life of bearing (hr)	480	500	510	550	
Evaluation test 3-2	Power consumption of bearing (Wh)	505	478	482	475	
	Electric power reduction rate (%)	-3.8	-9.0	-8.2	-9.5	

[0080] [Table 7]

			Test oil 3-5	Test oil 3-6	Test oil 3-7	Test oil 3-8
Composition (% by mass)	Lubricating base oil (based on total amount of lubricating base oil)	Base oil A	60	60	100	60
		Base oil B	40	40	-	40
	Grease composition (based on total amount of grease composition)	Lubricating base oil	82	80	82	83
		Thickener (simple soap)	-	-	-	-
		Thickener (complex soap)	16	-	16	16
		Thickener (urea)	-	18	-	-
		Molybdenum dithiocarbamate (in terms of amount of molybdenum element, mass ppm)	-	-	1 (2900)	-
		Molybdenum dithiophosphate (in terms of amount of molybdenum element, mass ppm)	1 (800)	1 (800)	-	-
	Other additives	1	1	1	1	
Consistency of grease composition		255	250	250	245	
Evaluation test 3-1	Life of bearing (hr)	480	500	380	120	
Evaluation test 3-2	Power consumption of bearing (Wh)	480	485	525	481	
	Electric power reduction rate (%)	-8.6	-7.6	Reference	-8.4	

Industrial Applicability

[0081] The grease composition according to the present invention attains a significant effect that the amount of electric power consumed during rotation of bearings is small. Accordingly, the grease according to the present invention can be suitably used in lubrication of mechanical components such as antifriction bearings, sliding bearings,

ball screws, linear guides, and gears, and are useful in industrial machines and mechanical systems for transportation.

CLAIMS

1. A grease composition comprising:

a lubricating base oil; and

a thickener,

5 wherein the lubricating base oil comprises

a first lubricating base oil having a %C_A of 2 to 8 and
a %C_P of 50 to 75, the %C_A and the %C_P being values determined by
n-d-M ring analysis according to ASTM D3238, and

10 a second lubricating base oil having a %C_A of 1 or less,
a %C_P of 70 or more, and a urea adduct value of 4% by mass or less,
the %C_A and the %C_P being values determined by n-d-M ring analysis
according to ASTM D3238,

15 and wherein a content of the first lubricating base oil is 5 to 90%
by mass and a content of the second lubricating base oil is 10 to 95% by
mass, based on a total amount of the lubricating base oil.

2. The grease composition according to claim 1, wherein the
grease composition has a consistency of 220 to 300.

3. The grease composition according to claim 1 or 2, further
comprising an organomolybdenum compound.

20 4. The grease composition according to claim 3, wherein the
organomolybdenum compound comprises at least one selected from
molybdenum dithiocarbamates and molybdenum dithiophosphates.

5. The grease composition according to any one of claims 1 to 4,
wherein the first lubricating base oil has a kinematic viscosity at 40°C
25 of 10 to 700 mm²/s and a viscosity index of 90 to 120.

6. The grease composition according to any one of claims 1 to 5,

wherein the second lubricating base oil has a kinematic viscosity at 40°C of 10 to 5000 mm²/s and a viscosity index of 110 to 150.

7. The grease composition according to any one of claims 1 to 6, wherein the second lubricating base oil comprises at least one selected from mineral oils and synthetic hydrocarbons.

8. The grease composition according to any one of claims 1 to 7, wherein the thickener comprises at least one selected from metal soap compounds and urea compounds.

9. A grease composition comprising:

a lubricating base oil;

a thickener; and

an organomolybdenum compound,

wherein the lubricating base oil comprises

a first lubricating base oil having a %C_A of 2 to 8 and

a %C_P of 50 to 75, the %C_A and the %C_P being values determined by n-d-M ring analysis according to ASTM D3238, and

a second lubricating base oil having a %C_A of 1 or less and a %C_P of 70 or more, the %C_A and the %C_P being values determined by n-d-M ring analysis according to ASTM D3238,

wherein a content of the first lubricating base oil is 5 to 90% by mass and a content of the second lubricating base oil is 10 to 95% by mass, based on a total amount of the lubricating base oil,

and wherein the grease composition has a consistency of 220 to 300.