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(54) **LUBRICATING OIL COMPOSITION FOR CONTINUOUSLY VARIABLE TRANSMISSION**

(57) The present invention provides a lubricating oil composition for a continuously variable transmission having a viscosity that is low enough to exhibit fuel saving properties but maintaining the viscosity required for a lubricating oil composition through the period of use in a system and also a higher metal-to-metal friction coefficient to ensure a high power transmitting capacity and providing a wet clutch friction characteristics and anti-shudder properties required for a transmission as well as having a low traction coefficient to achieve further improved fuel saving properties. The composition comprises a base oil having been adjusted so that the product

(EC×V40) of the mass percent (EC (mass%)) of a saturated cyclic component on the total base oil mass basis and the 40°C kinematic viscosity (V40 (mm²/s)) is 500 or less and the 100°C kinematic viscosity is from 3.6 to 4.1 mm²/s, (B) a phosphorus compound, (C) a calcium salicylate and/or a calcium sulfonate, (D) a boron-modified ashless dispersant in an amount of 0.001 to 0.008 percent by mass as boron, and (E) a friction modifier, each in a specific amount, the lubricating oil composition having a 100°C kinematic viscosity of 5.2 to 5.6 mm²/s and a viscosity index of 165 or greater.

EP 2 876 152 A1

Description**Technical Field**

5 [0001] The present invention relates to lubricating oil compositions for continuously variable transmissions, more specifically to the lubricating oil compositions with enhanced fuel saving properties, suitable for metal belt type continuously variable transmissions of automobiles.

Background Art

10 [0002] Recently, energy saving in automobiles and construction or agricultural machinery, i.e., fuel saving has become an urgent need in order to deal with environmental issues such as reduction in carbon dioxide emissions, and systems such as engines, transmissions, final reduction gears, compressors, or hydraulic power units have been strongly demanded to contribute to energy saving.

15 [0003] As one of means for saving fuel by transmissions, the use of continuously variable transmissions has been growingly expanding. This is for maximizing the fuel economy by driving an internal combustion engine under the most efficient driving conditions.

20 [0004] Furthermore, continuously variable transmissions have become highly efficient by reducing the size and weight thereof. Accompanied with this high efficiency, the lubricating oil used in the transmissions have been required to have fuel saving properties. For this requirement, a measure has been generally taken, wherein the lubricating oil is further lowered in viscosity or suppressed from being increased in viscosity at low temperatures so as to reduce the stir and frictional resistances in the torque converter, wet clutch, gear bearing mechanism and oil pump.

25 [0005] However, since the lubricating oil used in continuously variable transmissions is also used as a medium for a hydraulic control system, excess reduction of the viscosity causes some defects such as poor lubricity by wear or seizure due to insufficient oil film thickness, and failure of generation of sufficient hydraulic pressure caused by oil leakage from the control valves or oil pumps. High molecular weight additives, i.e., viscosity index improver is usually added to the base oil to suppress the viscosity from increasing particularly at low temperatures. However, even though the oil retain a proper viscosity when it is fresh, addition of the high molecular weight additive causes a problem that the additive cannot retain a proper viscosity because it is subjected to shear and is reduced in viscosity as the lubricating oil is used.

30 [0006] Conventionally, an automatic transmission oil has been provided, which is low in viscosity as the whole composition to enhance fuel efficiency but is increased in the base oil viscosity to retain properties such as shear stability, lubricating oil life and the like and also increased in high temperature high shear (HTHS) viscosity to enhance oil film retaining properties and to provide the composition with excellent anti-wear properties, anti-pitching properties, shear stability and low temperature viscosity characteristics (see, for example, Patent Literature 1 below). However, the oil
35 has been unable to meet the recent further fuel saving demand.

Citation List**Patent Literature**

40 [0007] Patent Literature 1: Japanese Patent Application Laid-Open Publication No. 2009-096925

Summary of Invention**Technical Problem**

45 [0008] The present invention has been achieved in view of the above-described current situation and has an object to provide a lubricating oil composition for continuously variable transmissions having a viscosity that is low enough to exhibit fuel saving properties but maintaining the viscosity required for a lubricating oil composition through the period
50 of use in a system and also a higher metal-to-metal friction coefficient to ensure a high power transmitting capacity and providing a wet clutch friction characteristics and anti-shudder properties required for a transmission as well as having a low traction coefficient to achieve further improved fuel saving properties.

Solution to Problem

55 [0009] As the results of extensive studies carried out to achieve the above object, the present invention has been accomplished on the basis of the finding that the object was able to be achieved by a lubricating oil composition comprising a selected combination of a specific base oil and specific additives.

[0010] That is, the present invention relates to a lubricating oil composition for a continuously variable transmission, comprising a base oil having been adjusted so that the product ($EC \times V40$) of the mass percent (EC (mass%)) of a saturated cyclic component on the total base oil mass basis and the 40°C kinematic viscosity (V40 (mm²/s)) is 500 or less and the 100°C kinematic viscosity is from 3.6 to 4.1 mm²/s, (B) a phosphorus compound in an amount of 0.01 to 0.03 percent by mass as phosphorus, (C) a calcium salicylate and/or a calcium sulfonate in an amount of 0.03 to 0.05 percent by mass as calcium, the elemental ratio (P/Ca) of phosphorus and calcium in the lubricating oil composition being from 0.3 to 0.7, (D) a boron-modified ashless dispersant in an amount of 0.001 to 0.008 percent by mass as boron, and (E) a friction modifier in an amount of 0.01 to 2 percent by mass on the total composition mass basis, the lubricating oil composition having a 100°C kinematic viscosity of 5.2 to 5.6 mm²/s and a viscosity index of 165 or greater.

Advantageous Effect of Invention

[0011] The continuously variable transmission lubricating oil composition of the present invention has a viscosity that is low enough to exhibit fuel saving properties but maintaining the viscosity required for a lubricating oil composition through the period of use in a system and a higher metal-to-metal friction coefficient to ensure a high power transmitting capacity and provides wet clutch friction characteristics and anti-shudder properties required for a transmission as well as having a low traction coefficient to achieve further improved fuel saving properties.

Description of Embodiments

[0012] The present invention will be described below.

[0013] The base oil used in the present invention is a base oil having been adjusted so that the product ($EC \times V40$) of the mass percent (EC (mass%)) of a saturated cyclic component on the basis of the total base oil mass and the 40°C kinematic viscosity (V40 (mm²/s)) is 500 or less and the 100°C kinematic viscosity is from 3.6 to 4.1 mm²/s and may be a mineral lubricating base oil, a synthetic lubricating base oil or a mixture thereof.

[0014] Examples of the mineral lubricating base oil which may be used in the present invention include paraffinic or naphthenic mineral base oils which can be produced by subjecting a lubricating oil fraction produced by atmospheric- or vacuum-distillation of a crude oil, to any one of or any suitable combination of refining processes selected from solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, catalytic dewaxing, hydrorefining, sulfuric acid treatment, and clay treatment; n-paraffins; and iso-paraffins. These base oils may be used alone or in combination at an arbitrary ratio.

[0015] Examples of preferred mineral lubricating base oils include the following base oils:

- (1) a distillate oil produced by atmospheric distillation of a paraffin base crude oil and/or a mixed base crude oil;
- (2) a whole vacuum gas oil (WVGO) produced by vacuum distillation of the topped crude of a paraffin base crude oil and/or a mixed base crude oil;
- (3) a wax produced by a lubricating oil dewaxing process and/or a Fischer-Tropsch wax produced by a GTL process;
- (4) an oil produced by mild-hydrocracking (MHC) one or more oils selected from oils of (1) to (3) above;
- (5) a mixed oil of two or more oils selected from (1) to (4) above;
- (6) a deasphalted oil (DAO) produced by deasphalting an oil of (1), (2) (3), (4) or (5);
- (7) an oil produced by mild-hydrocracking (MHC) an oil of (6); and
- (8) a lubricating oil produced by subjecting a mixed oil of two or more oils selected from (1) to (7) used as a feed stock and/or a lubricating oil fraction recovered therefrom to a normal refining process and further recovering a lubricating oil fraction from the refined product.

[0016] No particular limitation is imposed on the normal refining process used herein. Therefore, there may be used any refining process having been conventionally used upon production of a lubricating base oil. Examples of the normal refining process include (a) hydro-refining processes such as hydrocracking and hydrofinishing, (b) solvent refining such as furfural extraction, (c) dewaxing such as solvent dewaxing and catalytic dewaxing, (d) clay refining with acidic clay or active clay and (e) chemical (acid or alkali) refining such as sulfuric acid treatment and sodium hydroxide treatment. In the present invention, any one or more of these refining processes may be used in any combination and order.

[0017] The mineral lubricating base oil used in the present invention is particularly preferably a base oil produced by further subjecting a base oil selected from (1) to (8) described above to the following treatments.

[0018] That is, preferred are a hydrocracked mineral oil and/or wax-isomerized isoparaffinic base oil produced by hydrocracking or wax-isomerizing a base oil selected from (1) to (8) described above as it is or a lubricating fraction recovered therefrom and subjecting the resulting product as it is or a lubricating fraction recovered therefrom to dewaxing such as solvent dewaxing or catalytic dewaxing, followed by solvent refining or followed by solvent refining and then dewaxing such as solvent dewaxing or catalytic dewaxing.

[0019] Examples of synthetic lubricating base oils which may be used in the present invention include poly- α -olefins and hydrogenated compounds thereof; isobutene oligomers and hydrogenated compounds thereof; isoparaffins; alkylbenzenes; alkylnaphthalenes; diesters such as ditridecyl glutarate, di-2-ethylhexyl adipate, diisodecyl adipate, ditridecyl adipate and di-2-ethylhexyl sebacate; polyol esters such as trimethylolpropane caprylate, trimethylolpropane pelargonate, pentaerythritol 2-ethylhexanoate and pentaerythritol pelargonate; polyoxyalkylene glycols; dialkyldiphenyl ethers; and polyphenyl ethers.

[0020] Preferred synthetic lubricating base oils are poly- α -olefins. Typical examples of poly- α -olefins include oligomers or cooligomers of α -olefins having 2 to 32, preferably 6 to 16 carbon atoms, such as 1-octene oligomer, 1-decene oligomer, ethylene-propylene cooligomer, and hydrogenated compounds thereof.

[0021] Component (A), i.e., the lubricating base oil used in the present invention has a 100°C kinematic viscosity of 3.6 to 4.1 mm²/s, preferably 3.8 mm²/s or higher, and 4.0 mm²/s or lower. The use of a lubricating base oil with a 100°C kinematic viscosity of 4.1 mm²/s or lower renders it possible to produce a lubricating oil composition having a smaller frictional resistance at lubricating sites because of its small fluid resistance. The use of a lubricating base oil with a 100°C kinematic viscosity of 3.6 mm²/s or higher renders it possible to produce a lubricating oil composition which is sufficient in oil film formation and thus more excellent in lubricity and less in evaporation loss of the base oil under elevated temperature conditions.

[0022] One of the factors achieving the effect for improving the fuel saving properties of the present invention is a reduction in the traction coefficient. One major factor affecting the traction coefficient is the saturated cyclic component of a base oil. More the saturated cyclic component, more the traction coefficient is likely to be high. Another major factor is the base oil viscosity.

[0023] A lower base oil viscosity is more advantageous in fuel saving properties, but if a base oil has a too low viscosity, it causes various adverse effects and thus the base oil is desired to have a viscosity within the above-described range. Therefore, since the traction coefficient is largely influenced by the viscosity and saturated cyclic component of the base oil, the lubricating base oil used in the present invention has a product (ECxV40) of the mass percent (EC (mass%)) of a saturated cyclic component on the basis of the total base oil mass and the 40°C kinematic viscosity (V40 (mm²/s)) of necessarily 500 or less, preferably 470 or less, more preferably 450 or less, particularly preferably 400 or less, most preferably 350 or less so as to decrease the traction coefficient.

[0024] The saturated cyclic component is the value measured in accordance with ASTM D2786 test method, and the unit is converted to be percent by mass.

[0025] No particular limitation is imposed on the viscosity index of the lubricating base oil used in the present invention, which is, however, preferably 100 or greater, more preferably 110 or greater, particularly preferably 130 or greater, most preferably 135 or greater and preferably 160 or less. The use of a lubricating base oil having a viscosity index of greater than 100 renders it possible to produce a composition exhibiting excellent viscosity characteristics from low temperatures to high temperatures and having a low traction coefficient. The use of a lubricating base oil having a viscosity index of greater than 160 would deteriorate the viscosity characteristics at low temperatures.

[0026] No particular limitation is imposed on the sulfur content of the lubricating base oil used in the present invention, which is, however, preferably 100 ppm by mass or less, more preferably 10 ppm by mass or less, particularly preferably 1 ppm by mass or less. Reduction of the sulfur content of Component (A) renders it possible to produce a composition having a more excellent oxidation stability.

[0027] Component (A), i.e., lubricating base oil used in the present invention is particularly preferably (A1) a base oil produced by hydrocracking and catalytic dewaxing a feedstock containing 50 percent by mass or more of wax alone or a mixture of base oil (A1) and (A2) a hydrocracked and catalytically dewaxed base oil.

[0028] The wax content of the feedstock used to produce base oil (A1) produced by hydrocracking and catalytic dewaxing a feedstock containing 50 percent by mass or more of wax is preferably 60 percent by mass or more, particularly preferably 80 percent by mass or more.

[0029] A mixture of (A1) the base oil and (A2) the base oil contains (A1) the base oil in an amount of preferably 20 percent by mass or more, more preferably 40 percent by mass or more, particularly preferably 70 percent by mass or more, most preferably 90 percent by mass or more on the basis of the total base oil mass. A mixture containing 20 percent by mass or more of (A1) the base oil renders it possible to produce a composition having a viscosity index of 175 or greater and exhibiting excellent fuel saving properties because the traction coefficient can be also reduced.

[0030] This is because when branches having the same carbon number in the molecular structures constituting base oils are compared, base oil (A1) is longer in methylene chain than base oil (A2) and thus has properties that it has a higher viscosity index and reduce the traction coefficient. The properties are superior to those of the above-described poly- α -olefin synthetic oil.

[0031] Component (A), i.e., lubricating base oil used in the lubricating oil composition of the present invention is a lubricating base oil adjusted to have a 100°C kinematic viscosity of from 3.6 to 4.1 mm²/s and is preferably one or a mixture of two or more types selected from the (Aa) and (Ab) below:

(Aa) a mineral base oil having a 100°C kinematic viscosity of 1.5 to lower than 3.5 mm²/s, preferably 1.9 to 3.2 mm²/s, more preferably 2.2 to 2.9 mm²/s; and

(Ab) a mineral base oil having a 100°C kinematic viscosity of 3.5 to lower than 7 mm²/s, preferably 3.6 to 4.5 mm²/s. It will be understood that base oils (Aa) and (Ab) are any of base oils (A1) or (A2).

[0032] The use of a mixture of base oils having different viscosities can enhance the viscosity index of the resulting composition despite of the same viscosity and thus can improve fuel saving properties.

[0033] The lubricating oil composition of the present invention contains a phosphorus compound as Component (B).

[0034] No particular limitation is imposed on the phosphorus compound if it contains phosphorus per molecule, which may be, for example, phosphoric acid monoesters, phosphoric acid diesters, phosphoric acid triesters, phosphorus acid monoesters, phosphorus acid diesters, phosphorus acid triesters, thiophosphoric acid monoesters, thiophosphoric acid diesters, thiophosphoric acid triesters, thiophosphorus acid monoesters, thiophosphorus acid diesters, thiophosphorus acid triesters, all having a hydrocarbon group of 1 to 30 carbon atoms, salts of these esters and amines or alkanol amines or metal salts such as zinc salt of these esters.

[0035] Examples of the hydrocarbon group having 1 to 30 carbon atoms include alkyl, cycloalkyl, alkenyl, alkyl-substituted cycloalkyl, aryl, alkyl-substituted aryl and arylalkyl groups. One or more type of the groups may be contained in the compound. These hydrocarbon groups may be those containing sulfur in the main chain.

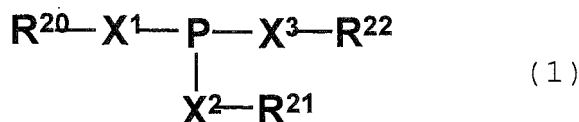
[0036] In the present invention, the phosphorus compound is preferably a phosphorus acid ester or phosphoric acid ester, having an alkyl group of 4 to 20 carbon atoms or an (alkyl) aryl group of 6 to 12 carbon atoms.

[0037] Alternatively, the phosphorus compound is more preferably one or a mixture of two or more types selected from phosphorus acid esters having an alkyl group of 4 to 20 carbon atoms and phosphorus acid esters having an (alkyl)aryl group of 6 to 12 carbon atoms.

[0038] Furthermore, the phosphorus compound is more preferably a phosphorus acid ester having an (alkyl)aryl group of 6 or 7 carbon atoms such as phenylphosphite and/or a phosphorus acid ester having an alkyl group of 4 to 8 carbon atoms. Among these phosphorus-containing additives, dibutylphosphite is most preferable.

[0039] The alkyl group may be straight-chain but is more preferably branched. This is because alkyl groups of fewer carbon atoms or branched result in higher metal-to-metal friction coefficient.

[0040] Component (B), i.e., phosphorus compound used in the present invention is preferably (B-1) a phosphorus compound represented by formula (1):

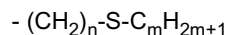


[0041] In formula (1), X¹, X² and X³ are each independently oxygen or sulfur, and R²⁰, R²¹ and R²² are each independently hydrogen, a hydrocarbon group having 1 to 30 carbon atoms or a hydrocarbon group having 3 to 30 carbon atoms containing at least one sulfur.

[0042] 1 In formula (1), preferably X¹, X² and X³ are all oxygen. At least one of R²⁰, R²¹ and R²² is preferably hydrogen. At least one of R²⁰, R²¹ and R²² is hydrogen, one or both of the others is preferably a straight-chain hydrocarbon group containing sulfur in the main chain. Particularly preferably, one of R²⁰, R²¹ and R²² is hydrogen and both of the others are a straight-chain hydrocarbon group containing sulfur in the main chain. Whereby, anti-wear properties and metal-to-metal friction coefficient can be enhanced.

[0043] The straight-chain hydrocarbon groups containing sulfur in the main chain are preferably those of different carbon number.

[0044] The straight-chain hydrocarbon group containing sulfur in the main chain is a group represented by the following formula:

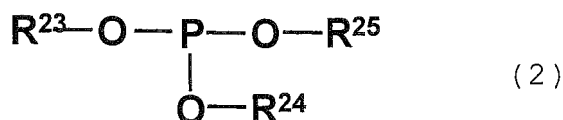


[0045] In the case where one of R²⁰, R²¹ and R²² is hydrogen and both of the others are straight-chain hydrocarbon groups containing sulfur in the main chain, the carbon number n of the alkylene group between oxygen bonding to phosphorus and sulfur contained in the main chain of the hydrocarbon group is preferably 4 or fewer, more preferably 2 or fewer. The carbon number m of at least one of the alkyl groups bonding to sulfur in the main chain of the hydrocarbon group is preferably 8 or more, more preferably 10 or more. The other is preferably 4 or fewer, more preferably 2 or fewer. The alkyl group having 4 or fewer carbon atoms is most preferably an alkyl group whose hydrogen at a terminal is substituted by a hydroxyl group. Whereby, anti-wear properties and metal-to-metal friction coefficient can be further

enhanced.

[0046] In the case where all of R²⁰, R²¹ and R²² are straight-chain hydrocarbon groups containing sulfur in the main chain, the carbon number n of the alkylene group between oxygen bonding to phosphorus and sulfur contained in the main chain of the hydrocarbon group is preferably 4 or fewer, more preferably 2 or fewer. The carbon number m of the alkyl groups bonding to sulfur in the main chain of the hydrocarbon group is preferably 8 or more, more preferably 10 or more. Whereby, anti-wear properties and metal-to-metal friction coefficient can be further enhanced.

[0047] Component (B), i.e., phosphorus compound of the lubricating oil composition of the present invention may be a mixture further containing (B-2) a phosphorus compound represented by formula (2):



[0048] In formula (2), R²³, R²⁴ and R²⁵ are each independently hydrogen or a hydrocarbon group having 3 to 30 carbon atoms.

[0049] When Component (B-1) and Component (B-2) are mixed, the ratio (B-2)/(B-1) of Component (B-2) and Component (B-1) on the phosphorus basis is preferably from 0 to 2, more preferably from 0 to 0.5. Whereby anti-wear properties and metal fatigue durability can be further enhanced.

[0050] The lower limit content of Component (B), i.e., phosphorus compound of the lubricating oil composition of the present invention is 0.01 percent by mass, preferably 0.015 percent by mass as phosphorus on the total composition mass basis while the upper limit content is 0.03 percent by mass, preferably 0.025 percent by mass. The content of Component (B) set to the above-described range renders it possible to produce a lubricating oil composition having excellent torque capacity and shifting properties and also excellent anti-shudder properties.

[0051] The lubricating oil composition of the present invention contains a calcium salicylate and/or a calcium sulfonate as Component (C).

[0052] No particular limitation is imposed on the structure of the calcium salicylate, which may be a calcium salt of salicylic acid having one or two alkyl group having 1 to 30 carbon atoms.

[0053] In the present invention, the calcium salicylate is preferably an alkylsalicylic acid calcium salt and/or an (over-based) basic salt thereof, wherein the component ratio of the monoalkylsalicylic acid calcium salt is from 85 to 100 percent by mole, the component ratio of the dialkylsalicylic acid calcium salt is from 0 to 15 percent by mole and the component ratio of the 3-alkylsalicylic acid calcium salt is from 40 to 100 percent by mole with the objective of further enhancing anti-shudder durability.

[0054] Examples of the alkyl group of the alkylsalicylic acid calcium salt include alkyl groups having 10 to 40, preferably 10 to 19 or 20 to 30, more preferably 14 to 18 or 20 to 26, particularly preferably 14 to 18 carbon atoms. These alkyl groups may be straight-chain or branched and primary and secondary alkyl groups.

[0055] The calcium salicylate may be a basic salt produced by heating an alkali metal or a neutral salt of calcium, together with an excess amount of a calcium salt in the presence of water or an overbased salt produced by reacting such a neutral salt with a base such as a hydroxide of calcium in the presence of carbonic acid gas, boric acid or borate.

[0056] Component (C) of the lubricating oil composition of the present invention may be a calcium sulfonate, the structure of which no particular limitation is imposed on.

[0057] The calcium sulfonate is, for example, preferably a calcium salt of an alkyl aromatic sulfonic acid produced by sulfonating an alkyl aromatic compound having a molecular weight of 100 to 1500, preferably 200 to 700.

[0058] Alternative examples of the calcium sulfonate include neutral alkaline earth metal sulfonates produced by reacting the above-mentioned alkyl aromatic sulfonic acid directly with an oxide or hydroxide of calcium or produced by once converting the alkyl aromatic sulfonic acid to an alkali metal salt such as a sodium salt or a potassium salt and then substituting the alkali metal salt with a calcium salt; but also basic calcium sulfonates produced by heating such neutral calcium sulfonates and an excess amount of an calcium salt or a calcium base in the presence of water; and carbonate overbased calcium sulfonates and borate overbased calcium sulfonates produced by reacting such neutral metal sulfonates with a base of calcium in the presence of carbonic acid gas and/or boric acid or borate.

[0059] In the present invention, the above-described neutral calcium sulfonates, basic calcium sulfonates, overbased calcium sulfonates and mixtures thereof may be used.

[0060] The base number of Component (C), i.e., calcium salicylate and/or calcium sulfonate used in the present invention is optional and usually from 0 to 500 mgKOH/g. However, it is preferred to use a calcium salicylate or a calcium sulfonate with a base number of 100 to 450 mgKOH/g, preferably of 200 to 400 mgKOH/g because it is excellent in an effect to enhance torque capacity. The term "base number" used herein denotes a base number measured by the perchloric acid potentiometric titration method in accordance with JIS K2501.

[0061] The content of Component (C) of the lubricating oil composition of the present invention is from 0.03 to 0.05

percent by mass, preferably from 0.035 percent by mass or more, more preferably 0.04 percent by mass or more and preferably 0.045 percent by mass or less as calcium on the total composition mass basis. The content of Component (C) within these ranges renders it possible to produce a lubricating oil composition which is excellent in torque capacity, shifting characteristics and anti-shudder properties.

[0062] In the lubricating oil composition of the present invention, the ratio (P/Ca) of the phosphorus content of Component (B) and the calcium content of Component (C) in the lubricating oil composition is from 0.3 to 0.7, preferably from 0.4 to 0.6, particularly preferably from 0.45 to 0.55. The content of Component (C) within these ranges renders it possible to produce a lubricating oil composition which is excellent in torque capacity, shifting characteristics and anti-shudder properties.

[0063] The lubricating oil composition of the present invention contains a boron-modified ashless dispersant as Component (D).

[0064] The ashless dispersant used in the present invention may be any ashless dispersant that is used in lubricating oil. Examples of the ashless dispersant include nitrogen-containing compounds having in per molecule at least one straight-chain or branched alkyl or alkenyl group having 40 to 400 and derivatives thereof and modified products of alkenylsuccinimides. Any one or more type selected from these ashless dispersants may be blended in the lubricating oil composition of the present invention.

[0065] The carbon number of the alkyl or alkenyl group of the ashless dispersant is preferably 40 to 400, more preferably 60 to 350. If the carbon number of the alkyl or alkenyl group is fewer than 40, the ashless dispersant would tend to be degraded in solubility in the lubricating base oil. Whereas, if the carbon number of the alkyl or alkenyl group is more than 400, the resulting lubricating oil composition would be degraded in low-temperature fluidity. The alkyl or alkenyl group may be straight-chain or branched but is preferably a branched alkyl or alkenyl group derived from oligomers of olefins such as propylene, 1-butene or isobutylene or a cooligomer of ethylene and propylene.

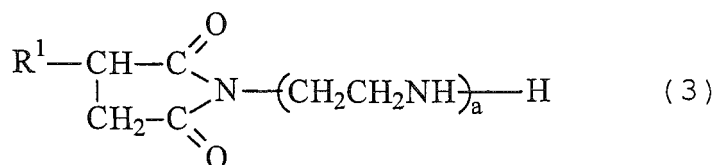
[0066] Specific examples of the ashless dispersant include the following compounds, one or more of which may be used:

(I) succinimides having in their molecules at least one alkyl or alkenyl group having 40 to 400 carbon atoms and derivatives thereof;

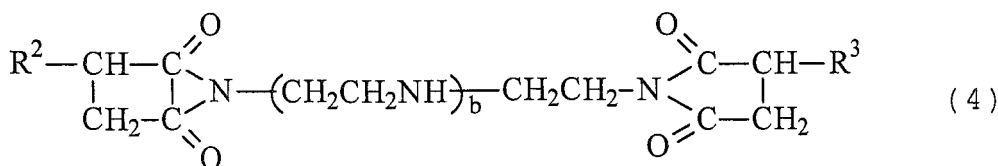
(II) benzylamines having in their molecules at least one alkyl or alkenyl group having 40 to 400 carbon atoms and derivatives thereof; and

(III) polyamines having in their molecules at least one alkyl or alkenyl group having 40 to 400 carbon atoms and derivatives thereof.

[0067] Specific examples of (I) succinimides include compounds represented by formulas (3) and (4):



[0068] In formula (3), R¹ is an alkyl or alkenyl group having 40 to 400, preferably 60 to 350, and b is an integer of 1 to 5, preferably 2 to 4



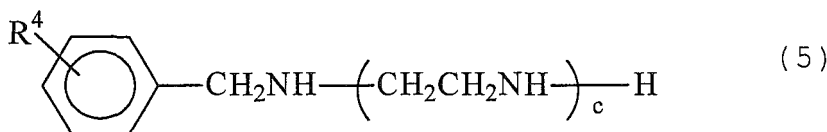
[0069] In formula (4), R² and R³ are each independently an alkyl or alkenyl group having 40 to 400, preferably 60 to 350 carbon atoms, and particularly preferably a polybutenyl group, and b is an integer of 0 to 4, preferably 1 to 3.

[0070] Succinimides include mono-type succinimides wherein a succinic anhydride is added to one end of a polyamine, as represented by formula (3) and bis-type succinimides wherein a succinic anhydride is added to both ends of a polyamine, as represented by formula (4). The lubricating oil composition may contain either type of the succinimides or a mixture thereof.

[0071] No particular limitation is imposed on the method for producing the succinimide. For example, a method may be used, wherein an alkyl or alkenyl succinimide produced by reacting a compound having an alkyl or alkenyl group

having 40 to 400 carbon atoms with maleic anhydride at a temperature of 100 to 200°C is reacted with a polyamine. Examples of the polyamine include diethylene triamine, triethylene tetramine, tetraethylene pentamine, and pentaethylene hexamine.

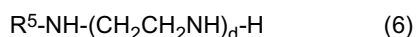
[0072] Specific examples of (II) benzylamines include compounds represented by formula (5):



[0073] In formula (5), R⁴ is an alkyl or alkenyl group having 40 to 400, preferably 60 to 350 and c is an integer of 1 to 5, preferably 2 to 4.

[0074] No particular limitation is imposed on the method for producing the benzylamines. They may be produced by reacting a polyolefin such as a propylene oligomer, polybutene, or ethylene- α -olefin copolymer with a phenol so as to produce an alkylphenol and then subjecting the alkylphenol to Mannich reaction with formaldehyde and a polyamine such as diethylenetriamine, triethylenetetramine, tetraethylenepentamine, or pentaethylenehexamine.

[0075] Specific examples of (III) polyamines include compounds represented by formula (6):



[0076] In formula (6), R⁵ is an alkyl or alkenyl group having 40 to 400, preferably 60 to 350 and d is an integer of 1 to 5, preferably 2 to 4.

[0077] No particular limitation is imposed on the method for producing the polyamines. For example, the polyamines may be produced by chlorinating a polyolefin such as a propylene oligomer, polybutene, or ethylene- α -olefin copolymer and reacting the chlorinated polyolefin with ammonia or a polyamine such as ethylenediamine, diethylenetriamine, triethylenetetramine, tetraethylenepentamine, and pentaethylenehexamine.

[0078] In the present invention, a so-called boron-modified ashless dispersant produced by allowing the above-described ashless dispersant to react with boric acid to neutralize the whole or part of the remaining amino and/or imino groups is used as Component (D). This boron-modified ashless dispersant is excellent in heat resistance and anti-oxidation properties and thus is effective to enhance the oxidation stability and corrosion-prevention properties of the lubricating oil composition for a continuously variable transmission of the present invention.

[0079] The above-described boron-modified compound is generally produced by allowing succinimide to react with boric acid to neutralize the whole or part of the remaining amino and/or imino groups. Examples of a method of producing a boron-modified succinimide are those disclosed in Japanese Patent Publication Nos. 42-8013 and 42-8014 and Japanese Laid-Open Patent Publication Nos. 51-52381 and 51-130408. More specifically, a boron-modified succinimide may be produced by mixing polyamine and polybutenylsuccinic acid (anhydride) with a boron compound such as boric acid, a boric acid ester, or a borate in a solvent including alcohols, organic solvent such as hexane or xylene, or a light fraction lubricating base oil and by heating the mixture under appropriate conditions.

[0080] No particular limitation is imposed on the boron content of the boron-containing ashless dispersant such as a boron-containing succinimide used in the present invention, which is, however, usually from 0.1 to 3 percent by mass, preferably 0.3 percent by mass or more, more preferably 2 percent by mass or less, more preferably 1.7 percent by mass or less, particularly preferably 1.5 percent by mass or less. The boron-containing ashless dispersant is preferably a boron-containing succinimide, particularly desirously a boron-containing bis-type succinimide, with a boron content within the above-described range. If the boron content is more than 3 percent by mass, concerns about stability are arisen.

[0081] No particular limitation is imposed on the boron/nitrogen mass ratio (B/N ratio) of the boron-containing ashless dispersant such as the above-described boron-containing succinimide, which is usually from 0.05 to 5, preferably 0.2 or greater and preferably 2 or less, more preferably 1.5 or less, more preferably 1.0 or less, particularly preferably 0.9 or less. The boron-containing ashless dispersant is preferably a boron-containing succinimide with a B/N ratio within this range, particularly desirously a boron-containing bis-type succinimide. If the B/N ratio exceeds 5, concerns about stability are arisen.

[0082] The content of Component (D), i.e., boron-modified ashless dispersant of the lubricating oil composition of the present invention is 0.001 percent by mass or more, preferably 0.003 percent by mass or more and 0.008 percent by mass or less, preferably 0.006 percent by mass or less as boron on the basis of the total mass of the composition.

[0083] If the boron content of the composition exceeds 0.008 percent by mass, the friction characteristics of a wet friction clutch would be degraded. If the boron content is less than 0.001 percent by mass, the resulting composition has no effect in enhancing the oxidation stability or corrosion prevention properties that is one of the properties of a continuously variable transmission lubricating oil composition.

[0084] The lubricating oil composition of the present invention contains Component (E) as a friction modifier.

[0085] The friction modifier is preferably a fatty acid ester-based friction modifier and/or a fatty acid amide-based friction modifier.

[0086] The fatty acid that is a raw material of a fatty acid ester-based compound or a fatty acid amide-based compound blended as the friction modifier preferably has a straight-chain structure, and the hydrocarbon group thereof may be an alkyl or alkenyl group. The carbon number is from 10 to 30, preferably 12 or more, more preferably 16 or more and preferably 26 or fewer, more preferably 24 or fewer. If the carbon number is fewer than 10, the friction modifier would be less effective. If the carbon number exceeds 30, the resulting composition would be deteriorated in low temperature viscosity characteristics.

[0087] The alcohol that is a raw material of an fatty acid ester-based compound blended as the friction modifier may be a monohydric alcohol or a polyhydric alcohol but is preferably a polyhydric alcohol. The polyhydric alcohols may be those of usually dihydric to decahydric, preferably dihydric to hexahydric. Specific examples of the polyhydric alcohols of dihydric to decahydric include dihydric alcohols such as ethylene glycol, diethylene glycol, polyethylene glycol (trimer to pentadecamer of ethylene glycol), propylene glycol, dipropylene glycol, polypropylene glycol (trimer to pentadecamer of propylene glycol), 1,3-propanediol, 1,2-propanediol, 1,3-butanediol, 1,4-butanediol, 2-methyl-1,2-propanediol, 2-methyl-1,3-propanediol, 1,2-pentanediol, 1,3-pentanediol, 1,4-pentanediol, 1,5-pentanediol, and neopentyl glycol; polyhydric alcohols such as glycerin, polyglycerin (dimer to octamer thereof, such as diglycerin, triglycerin, and tetraglycerin), trimethylolalkanes (trimethylolethane, trimethylolpropane, trimethylolbutane) and dimers to octamers thereof, pentaerythritol and dimers to tetramers thereof, 1,2,4-butanetriol, 1,3,5-pentanetriol, 1,2,6-hexanetriol, 1,2,3,4-butanetetrol, sorbitol, sorbitan, sorbitol-glycerin condensate, adonitol, arabitol, xylitol, and mannitol; saccharide such as xylose, arabinose, ribose, rhamnose, glucose, fructose, galactose, mannose, sorbose, cellobiose, maltose, isomaltose, trehalose, and sucrose; and mixtures thereof. Among these polyhydric alcohols, preferable examples include those of dihydric to hexahydric, such as ethylene glycol, diethylene glycol, polyethylene glycol (trimer to decamer of ethylene glycol), propylene glycol, dipropylene glycol, polypropylene glycol (trimer to decamer of propylene glycol), 1,3-propanediol, 2-methyl-1,2-propanediol, 2-methyl-1,3-propanediol, neopentyl glycol, glycerin, diglycerin, triglycerin, trimethylolalkanes (trimethylolethane, trimethylolpropane, trimethylolbutane) and dimers to tetramers thereof, pentaerythritol, dipentaerythritol, 1,2,4-butanetriol, 1,3,5-pentanetriol, 1,2,6-hexanetriol, 1,2,3,4-butanetetrol, sorbitol, sorbitan, sorbitol-glycerin condensate, adonitol, arabitol, xylitol, and mannitol, and mixtures thereof. More preferable examples include ethylene glycol, propylene glycol, neopentyl glycol, glycerin, trimethylolethane, trimethylolpropane, and mixtures thereof. Among these alcohols, glycerin is particularly preferable.

[0088] The amine that is a raw material of a fatty acid amide compound blended as a friction modifier may be ammonia, primary amine, a secondary amine but is preferably ammonia or a primary amine. Examples of the specific structure of the primary amine include diamines such as monoalkylamines, monoalkanolamines, aromatic amines, ethylenediamines and the like. Among these compounds, particularly preferred is ammonia.

[0089] Specific examples of (E) the fatty acid ester-based friction modifier used in the present invention include esters produced by reacting fatty acid selected from lauric acid, myristic acid, palmitic acid, palmitoleic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, eicosanoic acid, behenic acid, and lignoceric acid or mixtures thereof with alcohols selected from ethylene glycol, propylene glycol, neopentyl glycol, glycerin, trimethylolethane and trimethylolpropane or mixtures thereof. The structure of the ester may be a full ester wherein all of the hydroxyl groups in a polyhydric alcohol are esterified or a partial ester wherein a part of the hydroxyl groups remains unesterified. Particularly preferred is a partial ester of the above-described fatty acid having 16 to 20 carbon atoms and glycerin.

[0090] Specific examples of (E) the fatty acid amide-based friction modifier used in the present invention include amides produced by reacting fatty acid selected from lauric acid, myristic acid, palmitic acid, palmitoleic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, eicosanoic acid, behenic acid, and lignoceric acid or mixtures thereof with ammonia, methylamine, ethylamine, ethanolamine, aniline, ethylenediamine or a mixture thereof. The structure of the amide may be a primary amide, a secondary amide or a tertiary amide but is preferably a primary amide or a secondary amide. Particularly preferred is a primary amide of the above-described fatty acid having 16 to 20 carbon atoms and ammonia.

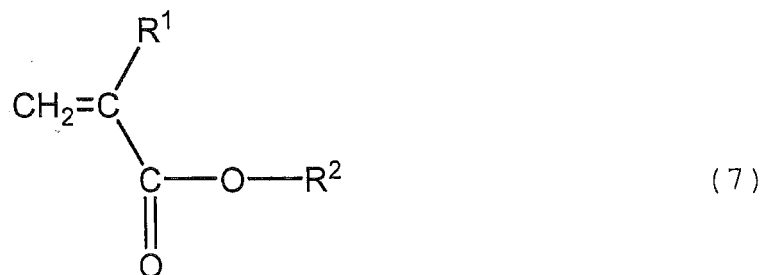
[0091] The use of a fatty acid ester-based compound and/or a fatty acid amide-based friction modifier as a friction modifier in the lubricating oil composition of the present invention can ensure anti-shudder properties without decreasing the metal-to-metal friction coefficient.

[0092] The content of Component (E) is from 0.01 to 2 percent by mass, preferably from 0.05 percent by mass or more and preferably 1.0 percent by mass or less, more preferably 0.5 percent by mass or less, more preferably 0.2 percent by mass or less on the total composition mass basis. If the content is less than 0.01 percent by mass, the friction modifier cannot exhibit its effect. If the content exceeds 2 percent by mass, low temperature solubility is concerned.

[0093] The lubricating oil composition of the present invention contains preferably a viscosity index improver as Component (F).

[0094] The viscosity index improver used in the lubricating oil composition of the present invention is preferably a

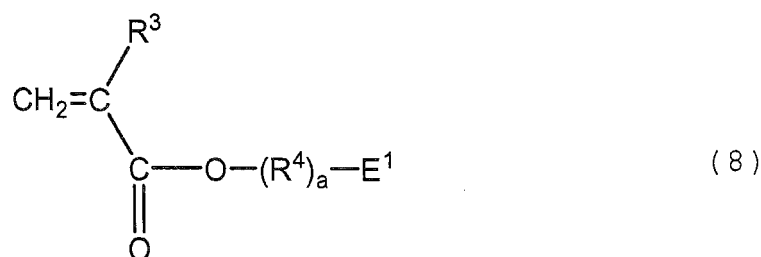
poly(meth)acrylate-based additive substantially containing a structural unit derived from a monomer represented by formula (7) below:



[0095] In formula (7), R^1 is hydrogen or methyl, preferably methyl, and R^2 is a hydrocarbon group having 1 to 30 carbon atoms.

[0096] Specific examples of the hydrocarbon group having 1 to 30 carbon atoms include alkyl groups having 1 to 30 carbon atoms, such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, straight-chain or branched pentyl, straight-chain or branched hexyl, straight-chain or branched heptyl, straight-chain or branched octyl, straight-chain or branched nonyl, straight-chain or branched decyl, straight-chain or branched undecyl, straight-chain or branched dodecyl, straight-chain or branched tridecyl, straight-chain or branched tetradecyl, straight-chain or branched pentadecyl, straight-chain or branched hexadecyl, straight-chain or branched heptadecyl, straight-chain or branched octadecyl, straight-chain or branched nonadecyl, straight-chain or branched eicosyl, straight-chain or branched heneicosyl, straight-chain or branched docosyl, straight-chain or branched tricosyl, and straight-chain or branched tetracosyl groups.

[0097] In addition to a structural unit derived from a monomer represented by formula (7), Component (F), i.e., poly(meth)acrylate-based additive used in the present invention may contain a structural unit derived from a monomer represented by formula (8) or (9) below.



[0098] In formula (8), R^3 is hydrogen or methyl, R^4 is an alkylene group having 1 to 30 carbon atoms, E^1 is an amine residue or heterocyclic residue having 1 or 2 nitrogen atoms and 0 to 2 oxygen atoms, and a is an integer of 0 or 1.



[0099] In formula (9), R^5 is hydrogen or methyl, and E^2 is an amine residue or heterocyclic residue having 1 or 2 nitrogen atoms and 0 to 2 oxygen atoms.

[0100] Specific examples of the groups represented by E^1 and E^2 include dimethylamino, diethylamino, dipropylamino, dibutylamino, anilino, toluidino, xylidino, acetlamino, benzoilamino, morpholino, pyrrolyl, pyrrolino, pyridyl, methylpyridyl, pyrrolidinyl, piperidinyl, quinonyl, pyrrolidonyl, pyrrolidono, imidazolino and pyrazino groups.

[0101] Preferred examples include dimethylaminomethyl methacrylate, diethylaminomethyl methacrylate, dimethyl-aminoethyl methacrylate, diethylaminoethyl methacrylate, 2-methyl-5-vinyl pyridine, morpholinomethyl methacrylate, morpholinoethyl methacrylate, N-vinyl pyrrolidone and mixtures thereof.

[0102] Specific examples of the viscosity index improver (Component (F)) include copolymers of monomers (Fa) to (Fd) represented by formula (7) and polar group-containing monomers (Fe) represented by formula (8) and/or (9) used

if necessary:

- (Fa) a (meth) acrylate wherein R^2 is an alkyl group having 1 to 4 carbon atoms;
- (Fb) a (meth) acrylate wherein R^2 is an alkyl group having 5 to 10 carbon atoms;
- (Fc) (meth) acrylates wherein R^2 is an alkyl group of 12 to 18 carbon atoms;
- (Fd) (meth)acrylate wherein R^2 is an alkyl group of 20 or more carbon atoms; and
- (Fe) polar group-containing monomers.

[0103] The structural ratio of the monomers in Component (F) used in the present invention is preferably the following ratio on the basis of the total amount of the monomers constituting the poly(meth)acrylate:

- Component (Fa): preferably 10 to 60 percent by mass, more preferably 20 to 50 percent by mass;
- Component (Fb): preferably 0 to 50 percent by mass, more preferably 0 to 20 percent by mass;
- Component (Fc): preferably 10 to 60 percent by mass, more preferably 20 to 40 percent by mass;
- Component (Fd): preferably 1 to 20 percent by mass, more preferably 5 to 10 percent by mass
- Component (Fe): preferably 0 to 20 percent by mass, more preferably 0 to 10 percent by mass, particularly preferably 0 percent by mass.

[0104] With this formulation, Component (F) can achieve both low temperature viscosity characteristics and a fatigue life extending effect for the resulting composition.

[0105] No particular limitation is imposed on the method for producing the above-described poly(meth)acrylate. For example, it can be easily produced by radical-solution polymerization of a mixture of monomers (Fa) to (Fe) in the presence of a polymerization initiator such as benzoyl peroxide.

[0106] The weight-average molecular weight of Component (F), i.e., poly(meth)acrylate-based additive is 60,000 or less, preferably 50,000 or less, more preferably 40,000 or less and 5,000 or greater, preferably 10,000 or greater, more preferably 20,000 or greater. If Component (F) has a weight-average molecular weight of more than 60,000, the resulting composition would be too low in shear stability and cannot retain the viscosity as required for the lubricating oil composition. If Component (F) has a weight-average molecular weight of smaller than 5,000, it would be less effective in enhancing the viscosity index and thus would deteriorate the fuel saving properties.

[0107] Component (F), i.e., poly(meth)acrylate-based additive used in the lubricating oil composition of the present invention is blended in such an amount that the 100°C kinematic viscosity and viscosity index of the lubricating oil composition are from 5.2 to 5.6 mm²/s and 165 or greater, respectively.

[0108] More specifically, the blend amount is 15 percent by mass or less, preferably 10 percent by mass or less, more preferably 6 percent by mass or less and 2 percent by mass or more, preferably 3 percent by mass or more, more preferably 4 percent by mass or more on the basis of the total mass of the composition. If Component (F) is blended in an amount of more than 15 percent by mass, the viscosity reduction caused by shear would be too large. If Component (F) is blended in an amount of less than 2 percent by mass, a sufficient composition viscosity cannot be ensured.

[0109] The 100°C kinematic viscosity and viscosity index of the lubricating oil composition of the present invention are necessarily from 5.2 to 5.6 mm²/s and 165 or greater, respectively.

[0110] If the composition has a 100°C kinematic viscosity of lower than 5.2, it causes a deterioration in extreme pressure properties or a decrease in fatigue life of bearings and thus possibly degrade the reliability of the system wherein the composition is used. If the composition has a 100°C kinematic viscosity of higher than 5.6 mm²/s or a viscosity index of less than 165, it would be less effective in fuel saving.

[0111] The lubricating oil composition of the present invention has a viscosity reduction rate of preferably 8% or less at 100°C 20 hours after a sonic shear stability test. The sonic shear stability test referred herein is determined by a method prescribed in JASO M 347.

[0112] As described above, the lubricating oil composition of the present invention is also used as a medium for a hydraulic system, and if reduced in viscosity causes the system to have problems such as failure to produce sufficient pressure, due to leakage of the oil from the oil pump or control valve. Thus, the lubricating oil to be used until the working life of a system ends needs to maintain the viscosity as required for this purpose.

[0113] The lubricating oil composition of the present invention needs to maintain a sufficient viscosity even if applied with repetitive shear force. What is meant by that the lubricating oil composition of the present invention has a viscosity reduction rate of 8% or less at 100°C 20 hours after a sonic shear stability test is the value to ensure that the composition has such a viscosity.

[0114] On the hand, the viscosity reduction rate can be reduced by blending a less amount of the viscosity index improver and on the other hand, the composition would be less effective in fuel saving. Therefore, the viscosity reduction rate range of the lubricating oil composition of the present invention is preferably 2% or greater and 8% or less, more preferably 3.5% or greater and 7% or less.

[0115] The lubricating oil composition of the present invention has preferably a traction coefficient of 0.02 or less at 40°C, an average speed of 3.0 m/s, a slip ratio of 10%, and a contact pressure of 0.4 GPa.

[0116] This traction coefficient is measured with a steel ball disk. While a disk with a radius of 13 cm is rotated at 286.7 rpm, a load of 20 N is applied on a ball with a radius of 1.27 cm placed on a position 10 cm apart radially from the center of the disk to measure the rotation torque applied to the ball at 40°C, an average speed of 3.0 m/s, a slip ratio of 10%, and a contact pressure of 0.4 GPa.

[0117] This condition does not reach what is called the complete elastohydrodynamic lubrication condition and thus is still in an intermediate region between the fluid lubrication condition and the elastohydrodynamic lubrication condition. Conventionally, the traction coefficient of a lubricating oil composition is measured at a high contact pressure, specifically a contact pressure of greater than 1 GPa, and a composition with a higher oil film formability, i.e., traction coefficient under such a high contact pressure condition is likely to form an oil film and has been evaluated as having an excellent lubricity under sever conditions.

[0118] However, the condition of measuring the traction coefficient in the present invention is that for measuring it under an intermediate surface pressure condition that is 0.4 GPa as described above and thus can be regarded as a typical condition for parts where the traction coefficient is involved with the resistance to lubrication among the parts of a machine to be lubricated except for ball bearings or roller bearings. Therefore, reduction of the traction coefficient under the above-described conditions reduces the resistance relating to the traction coefficient under lubricating conditions in a machine. That is, since the traction coefficient at 40°C, an average speed of 3.0 m/s, a slip ratio of 10% and a contact pressure of 0.4 GPa is set to 0.02 or less, the composition of the present invention can secure a fuel saving effect.

[0119] Under these conditions, the traction coefficient is 0.02 or less and is better as it is low, but as described above, is preferably 0.005 or greater to secure the lubricity for ball bearings or roller bearings under a higher contact pressure condition.

[0120] The lubricating oil composition of the present invention is required to be high in metal-to-metal friction coefficient as a continuously variable transmission lubricating oil composition. This is because if the metal-to-metal friction coefficient between the belt and pulleys of a metal belt type continuously variable transmissions is higher, the same torque can be transmitted even though the applied pressure is low, that is a high torque can be transmitted with a low hydraulic pressure.

[0121] The metal-to-metal friction characteristics between the belt and pulleys of a metal belt type continuously variable transmission is evaluated using Falex Block-on-Ring Test Machine. Specific conditions are as follows.

(Test conditions)

[0122]

ring: Falex S-10 Test Ring (EAE 4620Steel)

block: Falex H-60 Test Block

oil temperature: 80°C

applied load: 445N

slipping speed: 0.1 m/s

[0123] Under the foregoing conditions, the metal-to-metal friction coefficient is preferably 0.115 or greater, more preferably 0.118 or greater, most preferably 0.12 or greater and 0.14 or less. If the composition has a metal-to-metal friction coefficient of less than 0.115, it cannot exhibit the fuel saving properties intended by the present invention. If the composition has a metal-to-metal friction coefficient of greater than 0.14, the composition is unlikely to satisfy the anti-shudder properties. Furthermore, it increases the friction at bearings and thus would be adversely deteriorated in fuel saving properties.

[0124] The friction characteristics at the shifting clutch of a metal belt type continuously variable transmission is evaluated using SAE No. 2 test apparatus. As the friction characteristics after a lapse of 5000 cycles in an evaluation in accordance with JASO M348: 2002 using SD-1777X as a friction plate, the static friction coefficient (μ_t) is 0.13 or greater and 0.16 or less, and the μ_0/μ_d is preferably 0.9 or greater and 1.05 or less. If the static friction coefficient is less than 0.13, slipping at the shifting clutch would be concerned. If the static friction coefficient exceeds 0.16, the composition is unlikely to satisfy the anti-shudder properties. If the μ_0/μ_d exceeds 1.05, generation of shock at shifting would be concerned. If the μ_0/μ_d is less than 0.9, the composition is unlikely to ensure the static friction coefficient.

[0125] The anti-shudder properties at the lock-up clutch of a metal belt type continuously variable transmission is evaluated using a low velocity friction apparatus (LVFA) in accordance with JASO M349: 2010. In this evaluation, the $d\mu/dv$ at 0.3 m/s is preferably positive gradient. If the $d\mu/dv$ is negative gradient, shudder could be generated.

[0126] If necessary, the lubricating oil composition of the present invention may be blended with various additives other than those described above, such as viscosity index improvers, extreme pressure additives, dispersants, metallic detergents, anti-oxidants, corrosion inhibitors, rust inhibitors, demulsifiers, metal deactivators, pour point depressants,

seal swelling agents, anti-foaming agents, and dyes, alone or in combination in order to further enhance the properties of the composition or impart the composition with properties required for a lubricating oil.

[0127] Examples of the viscosity index improvers include those other than Component (F) that are the above-described poly(meth)acrylates, such as non-dispersant or dispersant type ethylene- α -olefin copolymers and hydrogenated compounds thereof; polyisobutylene and hydrogenated compounds thereof; styrene-diene hydrogenated copolymers; styrene-maleic anhydride ester copolymers; polyalkylstyrenes; and copolymers of (meth)acrylate monomers represented by formula (7) and unsaturated monomers such as ethylene/propylene/styrene/maleic anhydride.

[0128] When the lubricating oil composition of the present invention is blended with a viscosity index improver (excluding Component (F)), no particular limitation is imposed on the content thereof if the resulting composition meets the requirements regarding the 100°C kinematic viscosity and viscosity index. The content is usually from 0.1 to 15 percent by mass, preferably 0.5 to 5 percent by mass on the total composition mass basis.

[0129] Although the viscosity index of the lubricating oil composition is 165 or greater, it is preferably 175 or greater, more preferably 180 or greater, most preferably 190 or greater in view of the fuel saving effect.

[0130] As the extreme pressure additive other than Component (B) that is a phosphorus compound, the composition may be blended with at least one type of sulfur extreme pressure additive selected from sulfurized fats and oils, sulfurized olefins, dihydrocarbyl polysulfides, dithiocarbamates, thiaziazoles, and benzothiazoles.

[0131] As the dispersant other than Component (D) that is a boron-modified ashless dispersant, the composition may be blended with an ashless dispersant such as succinimide, benzylamine, polyamines, each having a hydrocarbon group having 40 to 400 carbon atoms or an acid- or sulfur-modified compound.

[0132] In the present invention, any one or more type of compound selected from these dispersants may be contained in any amount but usually in an amount of 0.01 to 20 percent by mass, preferably 0.1 to 10 percent by mass on the basis of the total mass of the composition. If the content exceeds 20 percent by mass, the resulting lubricating oil composition would be extremely degraded in low temperature fluidity.

[0133] Examples of the metallic detergent other than Component (C) that is calcium salicylate and/or calcium sulfonate include metallic detergents such as alkaline earth metal sulfonates, alkaline earth metal phenates and alkaline earth metal salicylates.

[0134] In the present invention, any one or more type of compound selected from these metallic detergents may be contained in any amount but usually in an amount of 0.01 to 10 percent by mass, preferably 0.1 to 5 percent by mass on the basis of the total mass of the composition.

[0135] The anti-oxidant may be any anti-oxidant that has been usually used in lubricating oil, such as phenol- or amine-based compounds.

[0136] Specific examples of the anti-oxidant include alkylphenols such as 2-6-di-tert-butyl-4-methylphenol; bisphenols such as methylene-4,4-bisphenol(2,6-di-tert-butyl-4-methylphenol); naphthylamines such as phenyl- α -naphthylamine; dialkyldiphenylamines; zinc dialkyldithiophosphates such as zinc di-2-ethylhexyldithiophosphate; and esters of (3,5-di-tert-butyl-4-hydroxyphenyl)fatty acid (propionic acid) with a monohydric or polyhydric alcohol such as methanol, octadecanol, 1,6-hexanediol, neopentyl glycol, thiodiethylene glycol, triethylene glycol and pentaerythritol.

[0137] Any one or more of compounds selected from these compounds may be contained in any amount, which is, however, usually from 0.01 to 5 percent by mass, preferably 0.1 to 3 percent by mass on the total composition mass basis.

[0138] Examples of the corrosion inhibitor include benzotriazole-, tolyltriazole-, thiadiazole-, and imidazole-types compounds.

[0139] Examples of the rust inhibitor include petroleum sulfonates, alkylbenzene sulfonates, dinonylnaphthalene sulfonates, alkenyl succinic acid esters, and polyhydric alcohol esters.

[0140] Examples of the demulsifier include polyalkylene glycol-based non-ionic surfactants such as polyoxyethylene-alkyl ethers, polyoxyethylenealkylphenyl ethers, and polyoxyethylenealkylnaphthyl ethers.

[0141] Examples of the metal deactivator include imidazolines, pyrimidine derivatives, alkylthiadiazoles, mercapto-benzothiazoles, benzotriazoles and derivatives thereof, 1,3,4-thiadiazolepolysulfide, 1,3,4-thiadiazolyl-2,5-bisdi-alkyldithiocarbamate, 2-(alkyldithio)benzimidazole, and β -(o-carboxybenzylthio)propionitrile.

[0142] The anti-foaming agent may be any compounds that have been usually used as anti-foaming agents for lubricating oil. Examples of such compounds include silicones such as dimethylsilicone and fluorosilicone. Any one or more of compounds selected from these compounds may be contained in any amount.

[0143] The seal swelling agent may be any compound that has been usually used as a seal swelling agent for lubricating oils. Examples of such a seal swelling agents include ester-, sulfur- and aromatic-based seal swelling agents.

[0144] The dye may be any compound that has been usually used and may be blended in any amount. The amount is usually from 0.001 to 1.0 percent by mass on the total composition mass basis.

[0145] When these additives are blended with the lubricating oil composition of the present invention, the corrosion inhibitor, rust inhibitor, and anti-foaming agent are each contained in an amount of 0.005 to 5 percent by mass, the metal deactivator is contained in an amount of 0.005 to 2 percent by mass, the seal swelling agent is contained in an amount of 0.01 to 5 percent by mass, and the anti-foaming agent is contained in an amount of 0.0005 to 1 percent by mass, all

on the total composition mass basis.

[0146] The lubricating oil composition of the present invention can be used in various applications such as lubricating oils for manual transmissions, automatic transmissions, continuously variable transmissions, final reduction gears and engine of automobiles and those for agricultural machines and construction machines. The lubricating oil composition is most suitably used for continuously variable transmissions. This is because the properties of the present invention are most effectively utilized in a continuously variable transmission having many parts to be subjected to shear and high contact pressure.

Examples

[0147] Hereinafter, the present invention will be described in more detail by way of the following examples and comparative examples, which should not be construed as limiting the scope of the invention.

(Examples 1 to 4, Comparative Examples 1 to 3)

[0148] Table 1 sets forth the results of viscosity temperature characteristics, EC×V40, viscosity reduction rate by shear test (JASO sonic method, 20 hours) and traction coefficient measurements of lubricating oil compositions (Examples 1 to 4) of the present invention and those for comparison (Comparative Examples 1 to 3).

(Examples 5 to 12, Comparative Examples 4 to 10)

[0149] Table 2 sets forth the results of metal-to-metal friction coefficient, shifting clutch characteristics (static friction coefficient, μ_0/μ_d) and anti-shudder properties measurements of lubricating oil compositions of the present invention (Examples 5 to 12) and those for comparison (Comparative Examples 4 to 10).

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3
Base oil	total base oil mass basis							
	Base oil 1	95	50	25	25			70
	Base oil 2		40	60	71	85	100	
	Base oil 3	5	10	15	4	15		30
Mixed base oil	Kinematic viscosity (40°C) (V40)	15.5	15.8	15.4	17.1	16.3	18.4	13.0
	(100°C)	3.8	3.8	3.7	4.0	3.8	4.2	3.3
	viscosity index	141	136	130	135	128	133	129
	saturated cyclic structure analysis							
	ALKANES (0-Rings)	80.5	73.6	68.9	72.9	66.1	71.6	68.4
	1-Ring	12.5	14.6	15.9	14.9	16.8	15.5	15.6
	2-Ring	5.8	8.3	9.9	8.7	10.9	9.4	9.5
	3-Ring	0.7	2.7	4.0	3.0	4.8	3.4	3.9
	4-Ring or more	0.4	0.9	1.4	0.4	1.4	0.1	2.6
	total of saturated cyclic components (EC)	19.5	26.4	31.1	27.1	33.9	28.4	31.6
Additives	saturated cyclic component x kinematic viscosity (40°C)	302	417	478	462	552	523	410
	total composition mass basis							
	viscosity index improver	4.2	4.2	4.2	3.0	4.2	2.4	6.6
Evaluation results	other additives	10	10	10	10	10	10	10
	kinematic viscosity (40°C)	22.2	22.7	23.0	23.5	24.2	24.7	21.7
	kinematic viscosity (100°C)	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	viscosity index	194	187	183	177	168	162	202
	Shear test (JASO sonic method, 20h)							
	kinematic viscosity after shear (100°C)	5.1	5.1	5.1	5.2	5.1	5.2	4.9
	viscosity reduction rate	6	6	6	4	6	3	10
	traction coefficient	0.011	0.015	0.017	0.017	0.024	0.021	0.014

Base oil 1: wax-hydroisomerized base oil (100°C kinematic viscosity: 3.9 mm²/s, total of saturated cyclic components: 17.1 mass%)

Base oil 2: hydrorefined base oil (100°C kinematic viscosity: 4.2 mm²/s, total of saturated cyclic components: 28.4 mass%)

Base oil 3: hydrorefined base oil (100°C kinematic viscosity: 2.5 mm²/s, total of saturated cyclic components: 65.3 mass%)

viscosity index improver: non-dispersant type polymethacrylate (Mw 30,000, main side chain hydrocarbon group is C16 to C22)

other additives: phosphorus acid ester-based antiwear agent (phosphorus amount (composition basis): 200 ppm by mass),

overbased Ca salicylate (Ca amount (composition basis): 400 ppm by mass), non-boronated succinimide (bis-type, amount (composition basis): 2.5 mass%)

boronated succinimide (bis-type, amount (composition basis): 1.5 mass%, B amount (composition basis): 50 ppm by mass), anti-oxidant (amine-based, phenol-based)

friction modifier (fatty acid ester compound (partial ester produced from glycerin and fatty acid having 16 to 20 carbon atoms), amount (composition basis): 0.1 mass%),

oil seal swelling agents, silicone-based anti-foaming agents and the like are contained

[Table 2]

	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10	Example 11	Example 12	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7	Comparative Example 8	Comparative Example 9	Comparative Example 10
Base oil															
total base oil mass basis															
Base oil 1	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Base oil 2	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Base oil 3	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Additives															
total composition mass basis															
B-1 (B) phosphorus-containing additive	200	200	200	250	200	200	200	200	300	100	400	200	200	200	200
C-1 (C) Oa detergent 1	400	200	400	400	300	450	400	400	300	400	400	200	600	400	400
C-2 (C) Oa detergent 2	200	400	400												
D-1 (D) non-boronated succinimide	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.4	2.5
D-2 (E) boronated succinimide	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	3.6	1.5
E-1 Friction modifier 1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
E-2 Friction modifier 2															
Y-1 other additives	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
P amount/Oa amount elemental ratio	0.50	0.50	0.50	0.63	0.67	0.44	0.38	0.50	1.00	0.25	1.00	1.00	0.33	0.50	0.50
B amount	50	50	50	50	50	50	50	50	50	50	50	50	50	120	50
Evaluation results															
metal-to-metal friction coefficient (LFW-1)	0.120	0.120	0.121	0.118	0.118	0.119	0.121	0.120	0.118	0.123	0.112	0.121	0.117	0.120	0.123
shifting clutch characteristics (SAE No.2 test)															
static friction coefficient (μ)	0.135	0.135	0.136	0.139	0.143	0.132	0.132	0.134	0.146	0.125	0.149	0.147	0.120	0.136	0.136
μ O/ μ d	1.00	1.00	1.00	1.02	1.03	0.99	1.00	0.99	1.08	0.97	1.07	1.08	0.95	1.06	1.00
anti-shudder properties (LVFA) d μ /dv (0.3 m/s)	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	positive gradient	negative gradient

Base oil 1: wax-hydrogenated isomerized base oil (100°C kinematic viscosity: 3.9 mm²/s, total of saturated cyclo components: 17.1 mass%)

Base oil 2: hydrorefined base oil (100°C kinematic viscosity: 4.2 mm²/s, total of saturated cyclo components: 28.4 mass%)

Base oil 3: hydrorefined base oil (100°C kinematic viscosity: 2.5 mm²/s, total of saturated cyclo component: 65.3 mass%)

phosphorus-containing additive: phosphorus acid ester

Oa detergent 1: overbased Oa salicylate (TBN 300)

Oa detergent 2: overbased Oa sulfonate (TBN 300)

Friction modifier 1: fatty acid ester compound (partial ester produced from glycerin and fatty acid having 16 to 20 carbon atoms)

Friction modifier 2: fatty acid amide compound (primary amide produced from ammonia and fatty acid having 16 to 20 carbon atoms)

Other additives non-dispersant type polymethacrylate (Mw 30,000), anti-oxidant (amine-based, phenol-based), oil seal swelling agent, silicone-based anti-foaming agent and the like are contained

[0150] As set forth in Tables 1 and 2, the lubricating oil compositions of the present invention retain a high metal-to-metal friction coefficient, is excellent in shifting clutch characteristics and anti-shudder properties and can achieve a further improvement in fuel saving properties due to the low traction coefficient.

Industrial Applicability

[0151] The lubricating oil composition of the present invention is excellent in fuel saving properties and suitably used for not only continuously variable transmissions but also for manual transmissions, automatic transmissions and final reduction gears.

Claims

1. A lubricating oil composition for a continuously variable transmission, comprising a base oil having been adjusted so that the product ($EC \times V40$) of the mass percent (EC (mass%)) of a saturated cyclic component on the total base oil mass basis and the 40°C kinematic viscosity (V40 (mm²/s)) is 500 or less and the 100°C kinematic viscosity is from 3.6 to 4.1 mm²/s, (B) a phosphorus compound in an amount of 0.01 to 0.03 percent by mass as phosphorus, (C) a calcium salicylate and/or a calcium sulfonate in an amount of 0.03 to 0.05 percent by mass as calcium, the elemental ratio (P/Ca) of phosphorus and calcium in the lubricating oil composition being from 0.3 to 0.7, (D) a boron-modified ashless dispersant in an amount of 0.001 to 0.008 percent by mass as boron, and (E) a friction modifier in an amount of 0.01 to 2 percent by mass on the total composition mass basis, the lubricating oil composition having a 100°C kinematic viscosity of 5.2 to 5.6 mm²/s and a viscosity index of 165 or greater.
2. The lubricating oil composition for a continuously variable transmission according to claim 1 wherein Component (E) is a fatty acid ester-based friction modifier and/or a fatty acid amide-based friction modifier.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/069266

A. CLASSIFICATION OF SUBJECT MATTER

C10M169/04(2006.01)i, C10M129/76(2006.01)n, C10M133/16(2006.01)n,
C10M137/02(2006.01)n, C10M139/00(2006.01)n, C10M159/22(2006.01)n,
C10M159/24(2006.01)n, C10N20/02(2006.01)n, C10N30/00(2006.01)n,
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, C10M129/76, C10M133/16, C10M137/02, C10M139/00, C10M159/22,
C10M159/24, C10N20/02, C10N30/00, C10N30/02, C10N30/06, C10N40/04

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 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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.
A	JP 2006-249408 A (Nippon Oil Corp.), 21 September 2006 (21.09.2006), claim 1; paragraphs [0250], [0255]; paragraph [0261], example 1 & US 2010/0035777 A1 & EP 1845151 A1 & WO 2006/073198 A1 & KR 10-2007-0094835 A & CN 101090960 A	1, 2
A	JP 2000-109875 A (Nippon Mitsubishi Oil Corp.), 18 April 2000 (18.04.2000), claims 1 to 3; paragraph [0027]; example 7 (Family: none)	1, 2

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

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search
10 October, 2013 (10.10.13)

Date of mailing of the international search report
22 October, 2013 (22.10.13)

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/069266

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003-113391 A (Nippon Oil Corp.), 18 April 2003 (18.04.2003), claims 1, 3, 4; paragraph [0001]; paragraph [0079], examples 1 to 5 & US 2004/0192562 A1 & WO 2003/031544 A1	1, 2

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/069266

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Continuation of A. CLASSIFICATION OF SUBJECT MATTER
(International Patent Classification (IPC))

C10N30/02(2006.01)n, C10N30/06(2006.01)n, C10N40/04(2006.01)n

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 51052381 A [0079]
- JP 51130408 A [0079]