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(54) OIL COMPOSITION FOR NON-STAGE TRANSMISSION

(57) The oil composition for infinite variable speed devices of the present invention comprises: (a) a lubricating oil base oil, (b) a polymethacrylate, (c) a phenate or sulfonate of alkaline earth metal, (d) an imido compound, (e) an (alkyl)phenyl (thio)phosphate, (f) a zinc dithiophosphate, and (g) a fatty acid amide compound. The oil composition exhibits a high coefficient of friction required for transmitting power to large output engines, and excellent capability of preventing abrasion and scratch noises. Therefore, the composition can be suitably used as a lubricating oil for a CVT for vehicles.

EP 1 055 722 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an oil composition for infinite variable speed devices, and particularly to an oil composition for infinite variable speed devices, for use with a belt pulley type CVT, having a high coefficient of friction, capable of maintaining the high coefficient of friction for a long period of time, being affected only slightly by abrasion, exhibiting improved μ -V characteristics without decreasing the coefficient of friction at high speed, and capable of preventing scratch noises.

BACKGROUND ART

[0002] Emissions of carbon dioxide have been controlled in recent years as a measure for preventing the greenhouse effect. One of the countermeasures which are desired includes further improvement in fuel consumption of vehicles. The mainstream of automatic transmissions (AT) for vehicles is a type in which a torque converter, a wet-type clutch, and planet gears are combined. A torque converter, however, exhibits a great energy loss because the power is transmitted via an automatic transmission fluid (ATF). Although a lock-up mechanism is employed to decrease power transmission loss, a remarkable decrease in power transmission loss is substantially difficult so long as a torque converter is used.

[0003] For this reason, a continuous variable transmission (CVT) using a metallic belt has been proposed. A belt pulley type CVT consists of a drive pulley and a belt for transmitting power, the belt having an element and a steel strip holding the element. This variable transmission can significantly decrease transmission losses. However, because the belt and the pulley can easily slip each other when used with large engines, generally the variable transmission has been used in vehicles with a small displacement. Recent requirements for decreasing fuel consumption, however, have stimulated a trend toward also using the variable transmission with high output engines.

[0004] To efficiently transmit the engine output, pulley and belt slip must be prevented. If the pressure for squeezing the belt to prevent slip is increased, however, the belt and pulley are easily abraded. For this reason, improvement not only in devices but also in lubricating oil has been desired to prevent slip and minimize abrasion of the belt and pulley. Specifically, development of lubricating oil which can exhibit sufficient lubricating capability for preventing abrasion and, at the same time, exhibit a frictional force above a certain level sufficient to prevent the belt from slipping from the pulley so as to provide adequate power transmission has been desired.

[0005] Japanese Patent Application Laid-open No. 9-25491 discloses a lubricating oil composition for preventing "scratch phenomenon" of CVT, comprising a lubricating base oil and an additive package which comprises (a) an over-based detergent such as an alkylaryl sulfonate over-based by using an alkali metal or an alkaline earth metal, (b) dialkyl dithiophosphate of a metal such as zinc diisooctyl dithiophosphate, (c) a sulfur-containing friction adjusting agent such as olefin sulfonate and fatty acid sulfonate, (d) fatty acid amide, and (e) a viscosity improvement agent such as polyolefin and the like .

[0006] Japanese Patent Application Laid-open No. 9-78079 proposes a lubricating oil composition exhibiting friction characteristics in which the coefficient of friction measured from frictional forces at sliding velocities in the range of 0-100 cm/s at a normal load of 200 lb using the LFW-1 test method according to ASTM D2714 increases together with the increase in the sliding velocity, and having a coefficient of friction in the range of 0.12-0.14 at a sliding velocity of 2.5 cm or less. Specifically, the lubricating oil comprises a mineral or synthetic base oil, sulfate ester, metal salt detergent, zinc dialkyl dithiophosphate, phosphoric acid ester, imide compound, and poly methacrylate. Use of this lubricating oil ensures large volume power transmission, while controlling stick-slip phenomenon due to slip among metals.

[0007] Japanese Patent Application Laid-open No. 9-100487 discloses a lubricating oil composition for infinite variable speed devices comprising a lubricating base oil; at least one sulfur-containing extreme pressure agent selected from fatty acid sulfates, thiocarbamates, and thioterpens; at least one phosphate extreme pressure agent selected from tricresyl phosphate, alkyl acidic amine phosphate, and alkenyl acidic amine phosphate; and an alkaline earth metal-containing detergent such as calcium phenate. The patent application claims that such a lubricating oil composition exhibits superior abrasion resistance and extreme-pressure property, can maintain a high coefficient of friction for a long period of time, and can transmit a large volume torque.

[0008] Japanese Patent Application Laid-open No. 9-263782 discloses a lubricating oil composition for infinite variable speed devices comprising a lubricating base oil, which may optionally contain a viscosity index improver; an ashless dispersant such as a sulfonate compound and an imide compound; an acid amide; an organic molybdenum compound such as molybdenum dithiophosphate and molybdenum dithiocarbamate; and an amine-based antioxidant. This composition has a minimum coefficient of friction of 0.1 or more at 100°C, and a ratio (μs/μd) of the coefficient of friction at a slip velocity of V (μd) and the coefficient of friction immediately before the slip velocity becomes zero (μs) of less than 1. The composition may further comprise a fatty acid derivative, partial ester compound, and sulfur-containing antioxidant. The inventors claim that the composition can maintain a high coefficient of friction for a long time and prevent scratch noises.

[0009] Although these prior arts emphasize improvement of coefficient of friction, there is still a strong desire for a lubricating oil with a higher coefficient of friction for transmitting a high engine power. In addition, since abrasion prevention performance and scratch noise prevention performance of these lubricating oil compositions are not necessarily sufficient, further improvement has been desired.

DISCLOSURE OF THE INVENTION

[0010] An object of the present invention is to provide an oil composition for infinite variable speed devices exhibiting a high coefficient of friction at a high speed, and having excellent abrasion prevention performance and scratch noise prevention performance.

[0011] The present inventors have conducted extensive studies on lubricating oils for metal belt type CVT to achieve the above object. As a result, the present inventors have found that the above-described object can be achieved by using specific types of additives selected from a great number of additives. This finding has led to the completion of the present invention.

[0012] Specifically, the present invention provides an oil composition for infinite variable speed devices comprising (a) a lubricating oil base oil, (b) a polymethacrylate, (c) at least one compound selected from phenates of alkaline earth metal and sulfonates of alkaline earth metal, (d) an imide compound, (e) at least one compound selected from phenyl phosphates, alkylphenyl phosphates, phenyl thiophosphates, alkylphenyl thiophosphates, (f) zinc dithiophosphate, and (g) a fatty acid amide compound.

[0013] Preferably, the polymethacrylate is a dispersing type and is added to the oil composition for infinite variable speed devices in the amount of 5-15 mass%. The above phenate of alkaline earth metal and sulfonate of alkaline earth metal are at least one compound selected from the calcium salt, magnesium salt, and barium salt. The amount used is of 0.5-3.0 mass% based on the oil composition for infinite variable speed devices. The above-mentioned imide compound is either or both of succinimide and boron-containing succinimide, and is added to the oil composition for infinite variable speed devices in the amount of 0.5-5.0 mass%. The amount of at least one of the above-mentioned compounds selected from phenyl phosphate, alkylphenyl phosphate, phenyl thiophosphate, and alkylphenyl thiophosphate is 0.1-2.0 mass% based on the oil composition for infinite variable speed devices. The above-mentioned zinc dithiophosphate is a commonly available compound of zinc and dithiophosphoric acid having an alkyl and/or aryl group, and is added to the oil composition for infinite variable speed devices in the amount of 0.05-0.2 mass%. The fatty acid amide compound is added to the oil composition for infinite variable speed devices in the amount of 0.1-3.0 mass%.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENT

[0014] The present invention will be described in more detail. Known mineral oils and synthetic oils can be used as the lubricating base oil of the present invention. Mineral base oils include, for example, oils prepared from neutral oil, bright stock, and distillate of atmospheric distillation which are obtained from crude oils. The process for preparing such mineral base oils comprises solvent extraction of these raw material oils using furfural or the like, dewaxing of the resulting raffinate using a solvent such as methyl ethyl ketone, and hydrogenation at high pressure to remove impurities such as sulfur. These oils may be used independently or after blending two or more of them in an appropriate ratio. As synthetic base oils, poly-α-olefins, polyhydric alcohol esters, polyalkylene glycols, and the like can be given. Mineral oils and synthetic oils can be used as the lubricating base oil either independently or in combinations.

[0015] The base oil used in the present invention preferably contains 30 mass% or more, preferably 50 mass% or more of a base oil having a viscosity index of 120 or more. Oils obtained by hydro-isomerization of waxes, highly hydrogenated oils, or the like, or synthetic oils can be used as such a base oil. If the amount of the base oil having a viscosity index of 120 or more is less than 30 mass%, the life span of the oil for infinite variable speed devices may decrease.

[0016] A dispersion type polymethacrylate is particularly preferable among polymethacrylates. Such a polymer can be obtained by copolymerization of an alkyl methacrylate monomer and a polar monomer. As a polar monomer, one or more compounds selected from diethylaminoethyl methacrylate, 2-methyl-5-vinyl pyrrolidone, N-vinyl pyrrolidone, and morpholino ethyl methacrylate can be preferably used. The molar ratio of an alkyl methacrylate monomer and a polar monomer in the copolymer is preferably from 80:20 to 95:5, in which the maximum dispersion effect can be obtained. The molecular weight of the polymer, in terms of number average molecular weight, is preferably in the range of 10,000-100,000 in view of shear stability and the like. The polymethacrylate is added to the oil composition for infinite variable speed devices in the amount of 5-15 mass%, and preferably 7-12 mass%. If less than 5 mass%, cold startability and the effect of abrasion prevention may decrease. The effect of abrasion prevention may also decrease when the amount of polymethacrylate is more than 15 mass%.

[0017] At least one alkaline earth metal selected from calcium, magnesium, and barium is used for the phenate of alkaline earth metal and sulfonate of alkaline earth metal. Calcium and magnesium are particularly preferable to improve the coefficient of friction characteristics.

[0018] The amount of at least one compound selected from the phenate of alkaline earth metal and sulfonate of alkaline earth metal is 0.5-3.0 mass%, and preferably 0.7-2.0 mass%, based on the oil composition for infinite variable speed devices. If less than 0.5 mass%, provision of high coefficient of friction and detergent effect may be insufficient; if more than 3.0 mass%, on the other hand, the coefficient of friction may decrease.

[0019] As the imide compound used in the present invention, succinimide and/or boron-containing succinimide is preferable. Those having alkenyl group may be used more preferably. The alkenyl succinimide is used for dispersing insoluble matters or sludge formed by the oxidation of organic substances. The additional effect is controlling a decrease in the coefficient of friction and preventing change over time of the coefficient of friction.

[0020] The imide compound is added to the oil composition for infinite variable speed devices in the amount of 0.5-5.0 mass%, and preferably 1.0-3.0 mass%. If less than 0.5 mass%, the coefficient of friction and dispersion effect may be impaired; if more than 5.0 mass%, on the other hand, the effect of abrasion prevention may decrease.

[0021] Phenyl phosphate, alkylphenyl phosphate, phenyl thiophosphate, and alkylphenyl thiophosphate used in the present invention are compounds having 1-3 hydrocarbon groups in the molecule, at least one of which is a benzene ring.

[0022] As specific examples of the hydrocarbon groups, phenyl groups and aryl groups having 7-18 carbon atoms having a benzene ring, and primary alkyl groups having 3-11 carbon atoms, secondary alkyl groups having 3-18 carbon atoms and β-position branched alkyl groups having 3-18 carbon atoms with no benzene ring, and the like can be given.

[0023] All the hydrocarbon groups in the molecule may be the same, one of the hydrocarbon groups may differ from the others, or all the hydrocarbon groups in the molecule may be different. The compounds having substantially two or more hydrocarbon groups with a benzene ring in the molecule are preferably used.

[0024] A mixture of two or more compounds having hydrocarbon groups with different structures in the molecules in an appropriate ratio can be used without a problem. The above-mentioned four compounds may be used either individually or in combination of two or more.

[0025] The amount of at least one compound selected from the phenyl phosphate, alkylphenyl phosphate, phenyl thiophosphate, and alkylphenyl thiophosphate may be 0.1-2.0 mass%, and more preferably 0.3-2.0 mass%, based on the oil composition for infinite variable speed devices. If the amount is less than 0.1 mass%, the oil composition has only a low coefficient of friction and cannot exhibit sufficient performance as the oil for infinite variable speed devices. Improvement in performance proportionate to the amount of addition cannot be seen if the amount exceeds 2.0 mass%.

[0026] As zinc dithiophosphate to be added to the base oil, commonly available zinc dithiophosphate can be used. As specific zinc dithiophosphate, at least one compound having a hydrocarbon group selected from the group consisting of primary alkyl groups having 3-11 carbon atoms, secondary alkyl groups having 3-18 carbon atoms, β-position branched alkyl groups having 3-18 carbon atoms, phenyl groups, and aryl groups having 7-18 carbon atoms can be preferably used. Of these, the compounds containing a phenyl group or aryl group are preferable from the viewpoint of stability of the coefficient of friction when used as the oil for infinite variable speed devices. The compounds containing a secondary alkyl group exhibit a superior abrasion preventing effect, and the compounds containing A primary alkyl group or a β-position branched alkyl group exhibit excellent stability against heat and oxidation. Therefore, it is desirable to select several types of zinc dithiophosphate compounds and suitably formulate these compounds according to the use.

[0027] When used as the oil composition for infinite variable speed devices of the present invention, a mixture of 10 parts by weight of zinc dithiophosphate having a phenyl group or an aryl group and 1-20 parts by weight of zinc dithiophosphate having a primary alkyl group is preferable. This combination is by no means limitative, and any readily available compounds can be used without a problem.

[0028] Inclusion of dithiophosphates containing one hydrocarbon group as impurities is unavoidable. Such compounds may be used as is, inasmuch as the solubility in base oils is not affected.

[0029] The zinc dithiophosphate is added to the oil composition for infinite variable speed devices in the amount of 0.05-0.2 mass% as zinc, and preferably 0.074-0.2 mass%. If the amount is less than 0.05 mass%, not only the coefficient of friction decreases, but also the abrasion preventive effect is lowered. Improvement in performance proportionate to the amount cannot be seen if the amount exceeds 0.2 mass%.

[0030] As the fatty acid amide compound used as a friction adjustment agent in the present invention, any conventional fatty acid amide compound can be used. There are no specific limits to the types of the fatty acid amide compounds. For instance, the fatty acid alkanol amides described below can be preferably used.

[0031] As fatty acids in the fatty acid amide compounds, fatty acids having preferably 7-22 carbon atoms, more preferably 8-20 carbon atoms, can be used. Specific examples include saturated fatty acids such as octanoic acid, decanoic acid, dodecanoic acid, tetradecanoic acid, hexadecanoic acid, and octadecanoic acid, unsaturated fatty acids such as oleic acid, mixtures of these fatty acids, and mixed fatty acids of naturally occurring fatty acids originating from animals or plants. Of these, unsaturated fatty acids such as oleic acid are desirable because of the low melting point. Diethanolamine, monoethanolamine, monoisopropanol amine, and mixtures of these can be given as amines used in the fatty acid alkanol amide.

[0032] Given as specific compounds obtained from the above fatty acids and amines are dodecanoic acid (lauric acid) monoethanol amide, dodecanoic acid diethanol amide, octadecanoic acid diethanol amide, octadecanoic acid monoethanol amide, oleic acid diethanol amide, oleic acid monoethanol amide, coconut oil fatty acid diethanol amide, coconut oil fatty acid monoethanol amide, tetradecanoic acid (myristic acid) diethanol amide, tetradecanoic acid monoethanol amide, dodecanoic acid tetradecanoic acid diethanol amide, hexadecanoic acid (palmitic acid) diethanol amide, hexadecanoic acid monoethanol amide, dodecanoic acid iso-propanol amide, iso-octadecanoic acid diethanol amide, iso-octadecanoic acid monoethanol amide, palm kernel oil fatty acid diethanol amide, palm kernel oil fatty acid monoethanol amide, and the like. Among these, dodecanoic acid diethanol amide, oleic acid diethanol amide, and coconut oil fatty acid diethanol amide are especially desirable because of the excellent effect and easy availability.

[0033] These fatty acid alkanol amides can be prepared by a process comprising, for example, providing a prescribed amount of fatty acid, adding twice that amount (mol) of diethanolamine, monoethanolamine, or monoisopropanol amine to the fatty acid, and performing a dehydration condensation reaction while heating in a nitrogen gas stream. In the same manner as in the case of salts of N-alkyl propylene diamine fatty acid, the fatty acid used need not be a single compound, but mixtures of two or more fatty acids, or fatty acid mixtures originating from naturally occurring substances can be used without a problem.

[0034] The fatty acid amide compound is added to the oil composition for infinite variable speed devices in the amount of 0.1-3.0 wt%, and preferably 0.5-2.0 wt%. If the amount is less than 0.1 wt%, the effect of scratch noise prevention is impaired. If the amount is more than 3.0 wt%, the coefficient of friction is decreased. The addition of fatty acid alkanol amide in the above range can effectively prevent scratch noises.

[0035] Scratch noises are occurred by sticking and slipping among elements of belt assemblies (frame/ring, ring/ring) of belt-type CVT. The sticking and slipping phenomenon occurs when the coefficient of friction decreases with the increase in the slipping speed. For this reason, the greater the value of the following formula, the less the sticking and slipping phenomenon occurs and, accordingly, the less the noises occur.

(Coefficient of friction at high speed) - (Coefficient of friction at low speed)

[0036] The relationship between the coefficient of friction (μ) and the speed is commonly called the μ-V characteristic. In some cases, the above value is negative (-). However, the larger the value, the better the performance.

[0037] The oil composition for infinite variable speed devices of the present invention exhibits excellent μ-V characteristics, as shown in examples which are discussed later. This is thought to be mainly due to the addition of the fatty acid amide compound which causes negative gradient μ-V characteristics to shift to positive gradient μ-V characteristics without decreasing the coefficient of friction at high speed. Even when the fatty acid amide compound cannot change a negative gradient to a positive gradient, this compound can at least reduce the degree of negative gradient. Therefore, the superior μ-V characteristics of the present invention are considered to be the result of the above-mentioned combinations of lubricating base oil and additives (a) to (g), or at least the result of sufficient exhibition of the capability of the fatty acid amide compound to improve the μ-V characteristics by the above-mentioned combinations.

[0038] The oil composition for infinite variable speed devices of the present invention exhibits the following effects which are brought about from the above-mentioned combinations of the lubricating base oil and additives.

(1) Exhibits a high coefficient of friction at high speed.
(2) Exhibits particularly superior μ-V characteristics.
(3) Exhibits only a small amount of scratch noise.
(4) Exhibits only a small amount of abrasion.

[0039] Since the oil composition for infinite variable speed devices of the present invention exhibits a high coefficient of friction at high speed and superior μ-V characteristics, the composition is suitable for use as a lubricating oil for CVT which transmits the power of high output, large volume engines having a high torque at a low speed. The oil composition is also effective for use in comparatively large vehicles.

[0040] In addition to the above-described additives, antioxidants, rust preventives, pour point depressants, metal deactivators, and the like which are conventionally used with lubricating oils can be added to the oil composition for infinite variable speed devices of the present invention insofar as the effect of the present invention is not impaired.

[0041] As antioxidants, a phosphorus-containing antioxidant, phenol-based antioxidant, and amine-based antioxidant can be used either individually or in combinations of two or more. The antioxidant is added to the oil composition for infinite variable speed devices in the amount of 0.1-3.0 mass%. If less than 0.1 mass%, anti-oxidizing capability may be insufficient. <u>If more than 3.0 mass%, too great an amount of oxidizing decomposition products may be produced, resulting in formation of sludge and decrease in the coefficient of friction.</u>

[0042] Given as examples of the phosphorus-containing antioxidants are bis (2,4-di-t-butylphenyl)pentaerythritol diphosphite, phenyldiisodecyl phosphite, diphenyldiisooctyl phosphite, diphenyldiisodecyl phosphite, triphenyl phosphite, trisnonylphenyl phosphite, tris-dinonylphenyl phosphite, tris-(2,4-di-t-butylphenyl) phosphite, distearyl pentaerythritol diphosphite, bis (nonylphenyl) pentaerythritol diphosphite, 4,4'-isopropylidenediphenolalkyl phosphite, 4,4'-butylidene bis(3-methyl-6-t-butylphenylditridecyl phosphite), 1,1,3-tris(2-methyl-4-di-tridecylphosphite-5-t-butylphenyl) butane, tetrakis(2,4-di-t-butylphenyl)-4,4'-bisphenylene diphosphite, 3,4,5,6-dibenzo-1,2-oxaphosphan-2-oxide, trilauryltrithiophosphite, tris (isodecyl) phosphite, tris(tridecyl) phosphite, phenyldi(tridecyl)phosphite, diphenyltridecyl phosphite, phenyl bisphenol A pentaerythritol diphosphite, 3,5-di-t-butyl-4-hydroxybenzyl diethyl phosphate, and the like. These compounds may be used either individually or in combinations of two or more.

[0043] Of these, aryl phosphite having an aryl group which has at least one, preferably two, alkyl groups is preferable in view of hydrolysis stability. Specifically, tris-(2,4-di-t-butylphenyl) phosphite, trisnonylphenyl phosphite, and tris (mono- & di-mixed nonylphenyl)phosphite can be suitably used. Inclusion of compounds containing 1-2 hydrocarbon groups is unavoidable when industrial grade reagents are used. Such compounds may be used as is inasmuch as the solubility in base oils is not affected.

[0044] The following compounds can be given as phenol-based antioxidants used in the present invention. 2,6-di-t-butyl phenol, 2-t-butyl-4-methoxyphenol, 2,4-dimethyl-6-t-butyl phenol, 2,4-diethyl-6-t-butylphenol, 2,6-di-t-butyl-p-cresol, 2,6-di-t-butyl-4-ethylphenol, 2,6-di-t-butyl-4-hydroxy methylphenol, 2,6-di-t-butyl-4-(N,N-dimethyl aminomethyl) phenol, n-octadecyl-β-(4'-hydroxy-3',5-di-t-butylphenyl) propionate, 2,4-(n-octylthio)-6-(4-hydroxy-3',5'-di-t-butyl anilino)-1,3,5-triazine, styrenated phenol, styrenated cresol, tochophenol, 2-t-butyl-6-(3'-t-butyl-5'-methyl-2'-hydroxy benzyl)-4-methylphenyl acrylate, 2,2'-methylenebis(4-methy 1-6-t-butylphenol), 2,2'-methylenebis(4-ethyl-6-t-butyl phenol), 2,2'-methylenebis(4-methyl-6-cyclohexylphenol), 2,2'-dihydroxy-3,3'-di(α-methylcyclohexyl)-5,5'-dimethyl diphenylmethane, 2,2'-ethylidenebis (2,4-di-t-butylphenol), 2,2'-butylidenebis(4-methyl-6-t-butylphenol), 4,4'-methylenebis(2,6-di-t-butylphenol), 4,4'-butylidenebis (3-methyl-6-t-butylphenol), 1,6-hexanediol bis[3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate], triethylene glycol bis-3 -(t-butyl -4-hydroxy-5-methylphenyl)propionate, N,N'-bis-[3 -(3,5-di-t-butyl-4-hydroxyphenyl)propionyl]hydrazine, N,N'-hexamethylene bis-(3,5-di-t-butyl-4-hydroxy)hydro cinnamide, 2,2'-thiobis(4-methyl-6-t-butylphenol), 4,4'-thiobis(3-methyl-6-t-butylphenol), 2,2-thiodiethylene bis-[3 (3,5- di- t-butyl-4-hydroxyphenyl)propionate], bis[2-t-butyl-4-methyl-6-(3-t-butyl-5-methyl-2-hydroxybenzy 1)phenyl]terephthalate, 1,1,3-tris(2-methyl-4-hydroxy-5-t-butylphenyl)butane, 1,3,5- trimethyl-2,4,6-tris(3,5-di-t-butyl-4-hydroxybenzyl)benzene, tris(3,5-di-t-4-hydroxy benzyl)isocyanurate, 1,3,5-tris(4-t-butyl-3-hydroxy-2,6-dimethylbenzyl)isocyanurate, tetrakis[methylene-3-(3',5'-di-t-butyl-4-hydroxyphenyl)propionate]methane, calcium(3,5-di-t-butyl-4-hydroxybenzylmonoethylphosphonate), propyl gallate, octyl gallate, lauryl gallate, 2,4,6-tri-t-butylphenol, 2,5-di-t-butylhydroquinone, 2,5-di-t-amylhydro quinone, 1,1,3-tris-(2-methyl-4-hydroxy-5-t-butylphenyl) butane, 1,3,5-trimethyl-2,4,6-tris-(3,5-di-t-butyl-4-hydroxybenzyl)benzene, 3,9-bis[2-{3-(3-t-butyl-4-hydroxy-5-methylphenyl)propionyloxy)-1,1-dimethylethyl)-2,8,10-tetraoxaspiro[5,5]undecane, and the like. These compounds may be used either individually or in combination of two or more.

[0045] Of these compounds, 2,6-di-t-butyl-p-cresol, 2,2'-methylenebis(4-methyl-6-t-butylphenol), 2,2'-methylenebis(4-ethyl-6-t-butyl-4-ethylphenol), 4,4'-methylenebis(2,6-di-t-butylphenol), and the like are preferred in view of easy availability and the superior effect in use with lubricating oil.

[0046] As amine-based antioxidant, p,p'-dioctyldiphenylamine, N-phenyl-N'-isopropyl-p-phenylenediamine, poly-2,2,4-trimethyl-1,2-dihydroquinoline, 6-ethoxy-2,2,4-trimethyl-1, 2- dihydroquinoline, thiodiphenylamine, 4-amino-p-diphenylamine, and the like can be given. These compound may be used either individually or in combination of two or more.

[0047] As examples of the metal deactivator, benzotriazole, tolyltriazole, benzotriazole derivatives having a hydrocarbon group with 2-10 carbon atoms, benzimidazole, imidazole derivatives having a hydrocarbon group with 2-10 carbon atoms, thiazole derivatives having a hydrocarbon group with 2-20 carbon atoms, 2-mercaptobenzothiazole, and the like. These compounds may be used either individually or in combination of two or more.

EXAMPLES

[0048] The present invention will be explained in more detail taking a lubricating oil for a belt type CVT as an example. All lubricating oils given as comparative examples had excellent performance. Therefore, the difference between the lubricating oils of the Examples and the lubricating oils in the Comparative Examples is small. However, the characteristics of the CVT oil of the present invention was proven to be much more excellent than the CVT oils of the Comparative Examples. The present invention is not limited to the following examples.

(Test methods)

[0049] The coefficient of friction, stability of the coefficient of friction, and lubricity of oil compositions for infinite variable speed devices were examined using the LFW-1 tester described in ASTM D2714. The coefficient of friction and the width of abrasion scars after 30 minutes from the start of the test were measured under the conditions of a load of 200 lbf, rotation of 140 rpm, and oil temperature of 110°C. A standard material was used as a test piece.

[0050] For oil samples exhibiting a sufficiently high coefficient of friction at 140 rpm, the coefficient of friction and the width of abrasion scars at 30 rpm were also measured. The coefficient of friction at 30 rpm was measured 30 minutes after the rotation was reached 30 rpm.

[0051] To evaluate the oil composition for infinite variable speed devices of the present invention, the following lubricating base oils (a) and additives (b) to (h) were used for preparing oil compositions in the Examples and Comparative Examples.

(Lubricating base oils)

[0052]

(a1) Lubricating base oil 1

40 mass% of base oil prepared by hydroisomerization of wax, 20 mass% of solvent-dewaxing base oil, and 40 mass% of neutral oil were blended. The base oil prepared by hydroisomerization of wax had a kinematic viscosity of 20 mm^2/s at 40°C and 4.5 mm^2/s at 100°C, a flash point of 224°C, a sulfur content of 10 ppm, an aromatic component of 0% by NDM ring analysis, and a viscosity index of 142. The solvent-dewaxing base oil had a kinematic viscosity of 96 mm^2/s at 40°C and 11 mm^2/s at 100°C, a flash point of 266°C, a sulfur content of 0.15 ppm, an aromatic component of 6.5% by NDM ring analysis, and a viscosity index of 97. The neutral oil had a kinematic viscosity of 12 mm^2/s at 40°C and 2.9 mm^2/s at 100°C, a flash point of 190°C, a sulfur content of 0.08 ppm, an aromatic component of 13% by NDM ring analysis, and a viscosity index of 80. (a2) Lubricating base oil 2

35 mass% of the above base oil prepared by hydroisomerization of wax, 25 mass% of the solvent-dewaxing base oil, and 40 mass% of the neutral oil were blended.

(a3) Lubricating base oil 3

70 mass% of the base oil prepared by hydroisomerization of wax and 30 mass% of the neutral oil were blended.

(a4) Lubricating base oil 4

65 mass% of the above base oil prepared by hydroisomerization of wax, 5 mass% of the solvent-dewaxing base oil, and 30 mass% of the neutral oil were blended.

(Additives)

[0053]

(b) Dispersion type polymethacrylate

Nitrogen-containing dispersion type polymethacrylate (Number average molecular weight: about 53,000)

(c1) Calcium phenate: Base number 240 mg KOH/g

(c2) Calcium sulfonate: Base number 300 mg KOH/g

(c3) Calcium phenate: Base number 320 mg KOH/g

(d1) Boron-containing succinimide

(d2) Succinimide

(e1) Triphenyl phosphate

(e2) Triphenyl thiophosphate

The following additives were provided for comparison.

(e3) Diisopropyl dithiophosphate propionate

(e4) Amine salt of acidic dithiophosphate

(e5) Tributyl phosphate

(f1) Zinc dithiophosphate (ZnDTP)

Industrial grade zinc diaryl dithiophosphate, with an aryl group having 12 carbon atoms

(f2) Zinc dithiophosphate (ZnDTP)

Zinc dialkyl dithiophosphate, with a primary alkyl group having 8 carbon atoms

(g1) Coconut oil fatty acid diethanolamide

The following friction adjustment agents were provided for comparison.

(g2) Sorbitan trioleate

(g3) Oleyl amine

(h1) Amine-based antioxidant (p,p'-dioctyldiphenylamine)

(h3) Phenol-based antioxidant (hindered phenol)

(Example 1)

[0054] Additives were added to the base oil (a1) to make a concentration of 7.0 mass% of polymethacrylate (b), 0.5 mass% of calcium phenate (c1), 0.8 mass% of calcium sulfonate (c2), 2.0 mass% of boron-containing succinimide (d1), 0.021 mass% (as zinc) of zinc aryl dithiophosphate (f1), 0.047 mass% (as zinc) of zinc alkyl dithiophosphate (f2), 0.3 mass% of amine-based antioxidant (h1),and 0.2mass % of phenol-based antioxidant (h2). Triphenyl phosphate (e1) was further added to the mixture so as to make a concentration of 0.5 mass%, followed by the addition of coconut oil fatty acid diethanolamide (g1) as a fatty acid amide to make a concentration of 1.0 mass%, thereby obtaining an oil composition for infinite variable speed devices. The concentrations are based on the total weight of the oil composition. The results of the LFW-1 test are shown in Table 1. The oil composition contributed not only to a high coefficient of friction, but also to reduced abrasion, even 30 minutes after the start of the test. Although the gradient of the rotation versus coefficient of friction was negative, the value was small as indicated by the difference (-0.007) of the coefficient of friction μ_{140} at 140 rpm and the coefficient of friction μ_{30} at 30 rpm.

(Example 2)

[0055] An oil composition for infinite variable speed devices was prepared in the same manner as in Example 1, except for replacing calcium phenate (c1) and calcium sulfonate (c2) in Example 1 with 1.0 mass% of calcium phenate (c3). The results of the LFW-1 test are shown in Table 1. The oil composition contributed to a high coefficient of friction, even 30 minutes after the start of the test. In addition, the gradient of the rotation versus coefficient of friction was positive, as indicated by the difference (+0.016) of the coefficient of friction μ_{140} at 140 rpm and the coefficient of friction μ_{30} at 30 rpm.

(Example 3)

[0056] An oil composition for infinite variable speed devices was prepared in the same manner as in Example 1, except for replacing the triphenyl phosphate (e1) in Example 1 with 0.5 mass% of triphenyl thiophosphate (e2), and changing the amount of the coconut oil fatty acid diethanol amide (g1) to 0.5 mass%. The results of the LFW-1 test are shown in Table 1. The oil composition contributed not only to a high coefficient of friction, but also to reduced abrasion, even 30 minutes after the start of the test. Although the gradient of the rotation versus coefficient of friction was negative, the value was small as indicated by the difference (-0.009) of the coefficient of friction μ_{140} at 140 rpm and the coefficient of friction μ_{30} at 30 rpm.

(Comparative Example 1)

[0057] Additives were added to the base oil (a1) to make a concentration of 7.0 mass% of polymethacrylate (b), 0.5 mass% of calcium phenate (c1), 0.8 mass% of calcium sulfonate (c2), 2.0 mass% of boron-containing succinimide (d1), 0.5 mass% of triphenyl thiophosphate (e2), 0.021 mass% (as zinc) of zinc aryl dithiophosphate (f1), 0.047 mass% (as zinc) of zinc alkyl dithiophosphate (f2), 0.3 mass% of amine-based antioxidant (h1), and 0.2 mass% of phenol-based antioxidant (h2). The concentrations are based on the total weight of the oil composition. The results of the LFW-1 test are shown in Table 1. The oil composition contributed to a high coefficient of friction 30 minutes after the start of the test. The gradient of the rotation versus coefficient of friction showed <u>a large negative value</u>, as indicated by the difference (-0.012) of the coefficient of friction μ_{140} at 140 rpm and the coefficient of friction μ_{30} at 30 rpm.

(Comparative Example 2)

[0058] Additives were added to the base oil (a2) to make a concentration of 7.0 mass% of polymethacrylate (b), 0.5 mass% of calcium phenate (c1), 0.8 mass% of calcium sulfonate (c2), 2.0 mass% of boron-containing succinimide (d1), 1.0 mass% of succinimide (d2), 0.0735 mass% (as zinc) of zinc aryl dithiophosphate (f1), 0.5 mass% of amine-based antioxidant (h1), and 0.5 mass% of dithiophosphate (e3). The concentrations are based on the total weight of the oil composition. The results of the LFW-1 test are shown in Table 1. The oil composition contributed to a high coefficient of friction and to a small amount of abrasion 30 minutes after the start of the test. However, the gradient of the rotation versus coefficient of friction showed a large negative inclination, as indicated by the difference (-0.020) of the coefficient of friction μ_{140} at 140 rpm and the coefficient of friction μ_{30} at 30 rpm.

(Comparative Example 3)

[0059] An oil composition for infinite variable speed devices was prepared in the same manner as in Comparative

Example 2, except for adding the oleyl amine (g3) to make a concentration of 0.1 mass%. The results of the LFW-1 test are shown in Table 1. The coefficient of friction 30 minutes after the start of the test was low.

(Comparative Example 4)

[0060] Additives were added to the base oil (a3) to make a concentration of 9.0 mass% of polymethacrylate (b), 0.5 mass% of calcium phenate (c1), 0.8 mass% of calcium sulfonate (c2), 2.0 mass% of boron-containing succinimide (d1), 0.3 mass% of amine-based antioxidant (h1), and 0.2 mass% of phenol-based antioxidant (h2). To the mixture, coconut oil fatty acid diethanol amide (g1) was further added to a concentration of 1.0 mass%, thereby obtaining an oil composition for infinite variable speed devices. The concentrations are based on the total weight of the oil composition. The results of the LFW-1 test are shown in Table 1. The coefficient of friction 30 minutes after the start of the test was low.

(Comparative Example 5)

[0061] Additives were added to the base oil (a3) to make a concentration of 9.0 mass% of polymethacrylate (b), 2.0 mass% of boron-containing succinimide (d1), 0.021 mass% (as zinc) of zinc aryl dithiophosphate (f1), 0.047 mass% (as zinc) of zinc alkyldithiophosphate (f2), 0.3 mass% of amine-based antioxidant (h1), and 0.2 mass% of phenol-based antioxidant (h2). To the mixture, triphenyl thiophosphate (e2) and coconut oil fatty acid diethanol amide (g1) were further added to a concentration of 0.5 mass% each, thereby obtaining an oil composition for infinite variable speed devices. The concentrations are based on the total weight of the oil composition. The results of the LFW-1 test are shown in Table 1. The coefficient of friction 30 minutes after the start of the test was low.

(Comparative Example 6)

[0062] Additives were added to the base oil (a4) to make a concentration of 7.0 mass% of polymethacrylate (b), 0.5 mass% of calcium phenate (c1), 0.8 mass% of calcium sulfonate (c2), 2.0 mass% of boron-containing succinimide (d1), 0.024 mass% (as zinc) of zinc aryl dithiophosphate (f1), 0.047 mass% (as zinc) of zinc alkyl dithiophosphate (f2), and 0.5 mass% of amine-based antioxidant (h1). 0.5 mass% of triphenyl phosphate (e1) and 0.5 mass% of sorbitan trioleate (g2) were further added to obtain an oil composition for infinite variable speed devices. The concentrations are based on the total weight of the oil composition. The results of the LFW-1 test are shown in Table 1. The coefficient of friction 30 minutes after the start of the test was low.

(Comparative Example 7)

[0063] Additives were added to the base oil (a1) to make a concentration of 7.0 mass% of polymethacrylate (b), 0.5 mass% of calcium phenate (c1), 0.8 mass% of calcium sulfonate (c2), 2.0 mass% of boron-containing succinimide (d1), 0.021 mass% (as zinc) of zinc aryl dithiophosphate (f1), 0.047 mass% (as zinc) of zinc alkyl dithiophosphate (f2), 0.3 mass% of amine-based antioxidant (h1), and 0.2 mass% of phenol-based antioxidant (h2). Amine salt of acidic thiophosphate (e4) was further added to the mixture to make a concentration of 0.5 mass%, followed by the addition of coconut oil fatty acid diethanolamide (g1) as a fatty acid amide to make a concentration of 1.0 mass%, thereby obtaining an oil composition for infinite variable speed devices. The concentrations are based on the total weight of the oil composition. The results of the LFW-1 test are shown in Table 1. The coefficient of friction 30 minutes after the start of the test was low.

(Comparative Example 8)

[0064] An oil composition for infinite variable speed devices was prepared in the same manner as in Comparative Example 7, except for replacing the amine salt of acidic thiophosphate (e4) in Comparative Example 7 with 0.5 mass% of tributyl phosphate (e5). The results of the LFW-1 test are shown in Table 1. The coefficient of friction 30 minutes after the start of the test was low.

Table 1

	LFW-1 test results				
	Coefficient of friction μ (after 30 minutes)			Width of abrasion scar (mm)	
	140 rpm	30 rpm	μ_{140rpm}-μ_{30rpm}	140 rpm	30 rpm
Example 1	0.139	0.146	-0.007	0.57	0.57
Example 2	0.145	0.129	0.016	0.63	0.66
Example 3	0.141	0.150	-0.009	0.55	0.62
Comparative Example 1	0.144	0.156	-0.012	0.59	0.61
Comparative Example 2	0.142	0.162	-0.020	0.55	0.59
Comparative Example 3	0.125	-	-	0.58	-
Comparative Example 4	0.125	-	-	0.58	-
Comparative Example 5	0.133	-	-	0.64	-
Comparative Example 6	0.127	-	-	0.58	-
Comparative Example 7	0.133	-	-	0.67	-
Comparative Example 8	0.134	-	-	0.60	-

INDUSTRIAL APPLICABILITY

[0065] The oil composition for infinite variable speed devices of the present invention exhibits a high coefficient of friction, resulting in operation with only a small power transmission loss and little abrasion. In addition, μ-V characteristics at a high speed are improved without decreasing the coefficient of friction and scratch noises are prevented. For these reasons, the oil composition can be suitably used as a lubricating oil for a belt type CVT which transmits power in large vehicles, and can contribute to the spread of low fuel consumption, comfortable vehicles.

Claims

1. An oil composition for infinite variable speed devices comprising: (a) a lubricating oil base oil, (b) a polymethacrylate, (c) at least one compound selected from phenate of alkaline earth metal and sulfonate of alkaline earth metal, (d) an imido compound, (e) at least one compound selected from phenyl phosphate, alkylphenyl phosphate, phenyl thiophosphate, alkylphenyl thiophosphate, (f) zinc dithiophosphate, and (g) a fatty acid amide compound.

2. The oil composition for infinite variable speed devices according to claim 1, wherein the polymethacrylate is a dispassion type and is contained in an amount of 5-15 mass% of the oil composition.

3. The oil composition for infinite variable speed devices according to claim 1 or claim 2, wherein the phenate of alkaline earth metal and sulfonate of alkaline earth metal are at least one compound selected from the calcium salt, magnesium salt, and barium salt, and are contained in an amount of 0.5-3.0 mass% of the oil composition.

4. The oil composition for infinite variable speed devices according to any one of claims 1 to 3, wherein the imide compound is either or both of succinimide and boron-containing succinimide, and is contained in the amount of 0.5-5.0 mass% of the oil composition.

5. The oil composition for infinite variable speed devices according to any one of claims 1 to 4, wherein the amount of at least one compound selected from phenyl phosphate, alkylphenyl phosphate, phenyl thiophosphate, and alkylphenyl thiophosphate is 0.1-2.0 mass% of the oil composition.

6. The oil composition for infinite variable speed devices according to any one of claims 1 to 5, wherein the zinc dithiophosphate has an alkyl group with 3-18 carbon atoms and/or an aryl group with 6-18 carbon atoms, and is contained in the amount of 0.05-0.2 mass% of the oil composition as zinc.

7. The oil composition for infinite variable speed devices according to any one of claims 1 to 6, wherein the amount of the fatty acid amide compound is 0.1-3.0 mass% of the oil composition.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/06286

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl[7] C10M161/00, 137/10, 137/04, 145/14, 133/16, 129/10, 135/10, 139/00//C10N10:02, 10:04, C10N30:00, 30:06, 40:04

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)

Int.Cl[7] C10M161/00, 137/10, 137/04, 145/14, 133/16, 129/10, 135/10, 139/00, C10N10:02, 10:04, C10N30:00, 30:06, 40:04

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

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

WPI (DIALOG)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 9-78079, A (SHOWA SHELL SEKIYU K.K.), 25 March, 1997 (25.03.97), Claim 2; table 1 (Family: none)	1-7
Y	EP, 805194, A1 (IDEMITSU KOSAN COMPANY LIMITED), 05 November, 1997 (05.11.97), Table 1, & WO, 9712950, A1 & JP, 9-100487, A, Table 1 & US, 5792731, A & KR, 98700400, A	1-7
Y	JP, 7-268375, A (TONEN CORPORATION), 17 October, 1995 (17.10.95), Claim 1; Tables 1-4, Par. No. [0064] (Family: none)	1-7
A	EP, 798367, A2 (Idemitsu Kosan Co., Ltd.), 01 October, 1997 (01.10.97), Table 1-1, & JP, 9-263782, A, Table 1, Par. No. [0025]	1-7
A	JP, 10-8081, A (Idemitsu Kosan Co., Ltd.), 13 January, 1998 (13.01.98) (Family: none)	1-7

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

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Date of the actual completion of the international search	Date of mailing of the international search report
09 February, 2000 (09.02.00)	22 February, 2000 (22.02.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/06286

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
EY	JP, 2000-1687, A (JAPAN ENERGY CORPORATION), 07 January, 2000 (07.01.00) (Family: none)	1-7
PY	JP, 11-293272, A (JAPAN ENERGY CORPORATION), 26 October, 1999 (26.10.99) (Family: none)	1-7

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