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(54) LUBRICATING OIL COMPOSITION

(57) A lubricating oil composition of the invention contains a first base oil having a kinematic viscosity at 100 degrees C in a range from 0.6 mm^2/s to 3.5 mm^2/s and a first poly(meth)acrylate having a mass average molecular weight in a range from 3×10^4 to 5×10^4.

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Description

TECHNICAL FIELD

[0001] The present invention relates to a lubricating oil composition, more specifically, to a lubricating oil composition suitably usable for a gear device that is usable in a manual transmission for automobiles and the like.

BACKGROUND ART

[0002] Energy-saving such as fuel efficiency and source-saving has recently been demanded for global environmental conservation. A lubricating oil composition for a gear device (i.e., a gear oil) usable in a manual transmission and a final reduction gear for automobiles and a step-up gear and a reducer for industrial machines is required to have an energy-saving performance through friction-loss reduction. However, if a viscosity of the gear oil is simply reduced (e.g., 6 mm^2/s or less of a kinematic viscosity at 100 degrees C), problems such as tooth hitting sound in a gear, gear abrasion, decrease in a fatigue life of a tooth flank and gear seizure may be caused by an insufficient viscosity at high temperatures, although a significant effect for decreasing an oil agitation loss in the device is exhibited. Accordingly, the gear oil is required to achieve viscosity reduction and friction-loss reduction at ordinary temperatures (e.g., from 20 degrees C to 80 degrees C) while maintaining oil-film retention performance at high temperatures (e.g., 100 degrees C or more). Simultaneously, the gear oil is required to reduce a load to a motor in starting the device by improving a low-temperature fluidity.

[0003] For instance, as such a gear oil, there is disclosed a lubricating oil composition containing: a lubricating base oil having a kinematic viscosity at 100 degrees C from 1.5 mm^2/s to 10 mm^2/s; 2 mass% to 40 mass% of a high-viscosity synthetic lubricating oil having a kinematic viscosity at 100 degrees C from 40 mm^2/s to 500 mm^2/s based on a total amount of the composition; and 0.01 mass% to 5 mass% of an extreme pressure additive such as a phosphorous extreme pressure additive based on the total amount of the composition (see Patent Literature 1). Another related art discloses that there is disclosed a fluid composition containing: 1 wt% to 49 wt% of a poly-alpha-olefin base stock having a kinematic viscosity at 100 degrees C from 40 mm^2/s to 500 mm^2/s; 1 wt% to 95 wt% of a lubricating oil base stock having a kinematic viscosity at 100 degrees C from 2 mm^2/s to 10 mm^2/s; 1 wt% to 49 wt% of a specified polyol ester; and a functional additive package, the fluid composition having a kinematic viscosity at 100 degrees C of at least 4 mm^2/s (see Patent Literature 2). Still another related art discloses that there is disclosed a gear oil composition containing, as a base oil, a mixture of a mineral oil or a synthetic oil having a kinematic viscosity at 100 degrees C from 3.5 mm^2/s to 7 mm^2/s and a mineral oil or a synthetic oil having a kinematic viscosity at 100 degrees C from 20 mm^2/s to 52 mm^2/s, and having a kinematic viscosity at 40 degrees C of 80 mm^2/s or less (see Patent Literature 3). Further related art discloses that a composition containing a base oil having a low viscosity from 3 mm^2/s to 3.8 mm^2/s and a polymer having a molecular weight from 10,000 to 35,000 as a viscosity index improver is known for improving the fuel efficiency (see Patent Literature 4).

CITATION LIST

PATENT LITERATURE(S)

[0004]

Patent Literature 1: WO2004/069967
Patent Literature 2: JP-A-2004-10894
Patent Literature 3: JP-A-2007-39480
Patent Literature 4: JP-A-2008-208212

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] However, the lubricating oil composition disclosed in Patent Literatures 1 to 3 cannot simultaneously attain the above characteristics required for the gear oil. The gear oil disclosed in Patent Literature 4 is insufficient in the fuel efficiency at ordinary temperatures.

[0006] Accordingly, an object of the invention is to provide a lubricating oil composition having a reduced viscosity at ordinary temperatures (from 20 degrees C to 80 degrees C) to reliably provide a favorable fuel efficiency and an excellent shear stability and being further capable of reducing friction loss.

MEANS FOR SOLVING THE PROBLEMS

[0007] In order to solve the above-mentioned problems, the invention provides a lubricating oil composition described below.

(1) According to an aspect of the invention, a lubricating oil composition contains: a first base oil having a kinematic viscosity at 100 degrees C in a range from 0.6 mm^2/s to 3.5 mm^2/s; and a first poly(meth)acrylate having a mass average molecular weight in a range from 3×10^4 to 5×10^4.
(2) The lubricating oil composition according to the above aspect of invention further contains an ester having a kinematic viscosity at 100 degrees C of 5 mm^2/s or less as a second base oil.
(3) The lubricating oil composition according to the above aspect of invention further contains a second poly(meth)acrylate having a mass average molecular weight in a range from 1.4×10^5 to 2×10^5.
(4) The lubricating oil composition according to the above aspect of invention further contains a molybdenum compound.
(5) The lubricating oil composition according to the above aspect of invention further contains at least one of a detergent dispersant, an extreme pressure agent, and an oiliness agent.
(6) The lubricating oil composition according to the above aspect of invention has the kinematic viscosity at 100 degrees C in a range from13.5 mm^2/s to 18.5 mm^2/s and a kinematic viscosity at 40 degrees C of 65 mm^2/s or less.
(7) The lubricating oil composition according to the above aspect of invention has a viscosity index of 245 or more.
(8) The lubricating oil composition according to the above aspect of invention has 15% or less of a reduction ratio of the kinematic viscosity at 100 degrees C in a shear stability test that is an ultrasonic shear test.
(9) The lubricating oil composition according to the above aspect of invention is used for a manual transmission.

[0008] According to the above aspect of the invention, a lubricating oil composition having a reduced viscosity at ordinary temperatures (from 20 degrees C to 80 degrees C) to reliably provide a favorable fuel efficiency and an excellent shear stability and being further capable of reducing friction loss can be provided.

DESCRIPTION OF EMBODIMENT(S)

[0009] A lubricating oil composition in an exemplary embodiment of the invention (hereinafter, also referred to as "the present composition") is provided by blending a base oil having a kinematic viscosity at 100 degrees C in a range from 0.6 mm^2/s to 3.5 mm^2/s with a poly(meth)acrylate having a mass average molecular weight in a range from 3×10^4 to 5×10^4. The present composition will be described in detail below.

[0010] The base oil used for the present composition has a kinematic viscosity at 100 degrees C in a range from 0.5 mm^2/s to 3.5 mm^2/s, preferably 0.6 mm^2/s to 3 mm^2/s. When the kinematic viscosity at 100 degrees C is 0.5 mm^2/s or more, evaporation loss is small. When the kinematic viscosity at 100 degrees C is 3.5 mm^2/s or less, power loss due to viscosity resistance is small, thereby improving fuel efficiency. When the kinematic viscosity at 100 degrees C exceeds 3.5 mm^2/s, an improvement in the viscosity index of the composition is difficult.

[0011] The base oil used in the present composition may be a mineral lubricating base oil or a synthetic lubricating base oil. The kind of the lubricating base oil is not particularly limited but may be suitably selected from any mineral oil and synthetic oil that have been conventionally used as a base oil of a lubricating oil for an automobile transmission.

[0012] Examples of the mineral lubricating base oil include a paraffinic mineral oil, an intermediate mineral oil and a naphthenic mineral oil. Examples of the synthetic lubricating base oil include polybutene, polyolefin (an alpha-olefin homopolymer or copolymer such as an ethylene-alpha-olefin copolymer), various esters (such as a polyol ester, a dibasic acid ester and phosphate), various ethers (such as a polyphenylether), polyglycol, alkylbenzene, and alkyl naphthalene.

[0013] As the base oil of the invention, one kind of the above mineral lubricating base oil may be used alone or two or more kinds thereof may be used in combination. In addition, one kind of the above synthetic lubricating base oil may be used alone or two or more kinds thereof may be used in combination. Further, one or more kinds of the above mineral lubricating base oil and one or more kinds of the above synthetic lubricating base oil may be used in combination.

[0014] A viscosity index of the base oil is preferably 70 or more, more preferably 100 or more, much more preferably 120 or more. In the base oil having a viscosity index of the aforementioned lower limit or more, a viscosity change due to temperature change is small and improvement in fuel efficiency is obtainable even at low temperatures.

[0015] The present composition contains the poly(meth)acrylate having a mass average molecular weight in a range from 3×10^4 to 5×10^4, preferably from 3.2×10^4 to 4.5×10^4. When the mass average molecular weight falls within the above range, shear stability is excellent and the viscosity index is sufficiently high.

[0016] A content of the poly(meth)acrylate is preferably in a range from 20 mass% to 45 mass% of a total amount of the composition, more preferably in a range from 25 mass% to 40 mass%. When the content of the poly(meth)acrylate is less than 20 mass%, blending effects may be insufficient. On the other hand, even when the content thereof exceeds

45 mass%, the blending effects is limitative.

[0017] The present composition preferably further contains an ester having a kinematic viscosity at 100 degrees C of 5 mm^2/s or less as another base oil. When such an ester is contained in the present composition, solubility of the poly(meth)acrylate is increased, so that whitening of the present composition can be inhibited. Note that the kinematic viscosity at 100°C of an entire mixture of the base oils is required not to exceed 3.5 mm^2/s.

[0018] A content of the ester is preferably in a range from 5 mass% to 20 mass% of the total amount of the composition, more preferably in a range from 8 mass% to 15 mass%. When the content of the ester is less than 5 mass%, the blending effects may be insufficient. On the other hand, also when the content thereof exceeds 20 mass%, the blending effects is limitative.

[0019] Examples of alcohol (unit) forming the ester include: a monool such as n-hexanol, n-heptanol, n-octanol, n-nonanol, n-decanol, n-undecanol, n-dodecanol, n-tridecanol, n-tetradecanol, oleyl alcohol, ethylhexanol, butyloctanol, pentylnonanol, hexyldecanol, heptylundecanol, octyldodecanol, methylheptadecanol, oleyl alcohol, benzylalcohol, 2-phenethylalcohol, 2-phenoxyethanol, ethyleneglycol monobenzylether, ethyleneglycol monophenylether, diethyleneglycol monobenzylether, diethyleneglycol monophenylether, phenol, crezol, xylenol, and alkylphenol; ethyleneglycol, diethyleneglycol, triethyleneglycol, polytetramethyleneglycol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, polyethyleneglycol (hydroxyl groups at both ends); a triol such as trimethylolpropane; and trimethylolethane; and a tetraol such as pentaerythritol.

[0020] Examples of a carboxylic acid (unit) forming the ester include: monocarboxylic acids such as n-butanoic acid, n-pentanoic acid, n-hexanoic acid, n-heptanoic acid, n-octanoic acid, n-nonanoic acid, n-decanoic acid, n-undecanoic acid, n-dodecanoic acid, n-tridecanoic acid, n-tetradecanoic acid, ethylhexanoic acid, butyloctanoic acid, pentylnonanoic acid, hexyldecanoic acid, heptylundecanoic acid, octyldodecanoic acid, methylheptadecanoic acid, oleic acid, benzoic acid, toluic acid, phenylacetic acid, and phenoxyacetic acid; and dicarboxylic acids such as adipic acid, azelaic acid, sebacic acid, 1,10-decamethylene dicarboxylic acid, phthalic acid, isophthalic acid, and terephthalic acid. One of the above may be used alone or a combination thereof may be used.

[0021] Examples of the ester formed from the above examples of alcohol and the carboxylic acid include: polyglycol benzoic acid esters such as polyethyleneglycol dibenzoate and polypropyleneglycol dibenzoate; linear hindered carboxylate such as n-octanoic acid tetraester of pentaerythritol and n-octanoic acid triester of trimethylolpropane; long chain diesters such as azelaic acid di-n-octyl ester and 1,10-decamethylene dicarboxylic acid ethylhexyl ester; long chain monoesters such as 16-methylheptadecanoic acid dodecyl ester and 2-heptyl undecanoic acid n-dodecyl ester; and long chain oleyl esters such as oleyl oleate and 16-methylheptadecyl oleate.

[0022] However, the above esters to be contained in the present composition are not necessarily manufactured from the carboxylic acid and alcohol. For instance, the above esters may be manufactured by ester interchange.

[0023] The present composition preferably further contains a poly(meth)acrylate having a mass average molecular weight in a range from 1.4×10^5 to 2×10^5, more preferably in a range from 1.6×10^5 to 1.8×10^5. By containing the poly(meth)acrylate having such a high molecular weight, the viscosity index of the present composition can be further improved. When the mass average molecular weight of the poly(meth)acrylate is less than 1.4×10^5, the viscosity-index improving effect is limitative. On the other hand, when the mass average molecular weight of the poly(meth)acrylate exceeds 2×10^5, the shear stability may be decreased.

[0024] A content of the poly(meth)acrylate is preferably in a range from 2 mass% to 7 mass%, more preferably in a range from 3 mass% to 6 mass%.

[0025] The present composition preferably further contains a molybdenum compound. Wear resistance of the present composition can be further improved by containing the molybdenum compound. For instance, wear of a synchronizer ring can be suppressed without decreasing a friction coefficient between the synchronizer ring and a gear cone in a manual transmission.

[0026] Examples of the molybdenum compound include MoDTC (molybdenum dialkyl dithiocarbamate) and MoDTP (molybdenum dialkyl phosphate). MoDTC is more preferable in terms of effects.

[0027] A content of the molybdenum compound is preferably in a range from 30 mass ppm to 300 mass ppm in terms of an Mo element amount based on the total amount of the composition, more preferably in a range from 50 mass ppm to 150 mass ppm. When the content of the molybdenum compound is less than 30 mass ppm, wear-resistance improving effects may be insufficient. On the other hand, even when the content of the molybdenum compound exceeds 300 mass ppm, the wear-resistance improving effects are limitative.

[0028] The present composition preferably further contains any one of a detergent dispersant, an extreme pressure agent, and an oiliness agent.

[0029] The detergent dispersant is classified into a metal detergent and an ashless dispersant. Examples of the metal detergent include sulfonate, phenate, salicylate and naphthenate of alkaline earth metal (e.g., calcium (Ca) and magnesium (Mg)). The metal detergent preferably has a total base number of 300 mg/KOH or more. The total base number herein means the total base number measured by potentiometer titration (base number perchloric acid method) based on the Item 7 of "Petroleum Products and Lubricating Oil - Examining Method of Neutralization Value" of JIS K2501. A content of the metal detergent is preferably in a range from 1 mass% to 2.5 mass% of the total amount of the composition in terms of the effects.

[0030] Preferable examples of the ashless dispersant include: polybutenyl succinimide, polybutenyl benzylamine, polybutenyl amine, and derivatives thereof (e.g., boron modified compounds thereof). A content of the ashless dispersant is preferably in a range from 0.5 mass% to 1.5 mass% of the total amount of the composition in terms of the effects.

[0031] Examples of the extreme pressure agent include sulfur, phosphorus, and boric extreme pressure agents. Examples of the sulfur extreme pressure agent include an olefin sulfide, a sulfurized fat and oil, an ester sulfide, thiocarbonates, dithiocarbamates and polysulfides. Examples of the phosphorus extreme pressure agent include zinc dithiophosphate, phosphite, alkyl or aryl acid phosphate or an amine salt thereof, and trialkyl or triaryl phosphate.

[0032] A contents of the extreme pressure agent is preferably approximately in a range from 0.1 mass% to 5 mass% of the total amount of the composition, more preferably in a range from 0.5 mass% to 3 mass%.

[0033] Examples of the oiliness agent include aliphatic monocarboxylic acid, polymerized fatty acid, hydroxyl fatty acid, aliphatic monoalcohol, aliphatic monoamine, aliphatic monocarboxylic acid amide, and a partial ester of polyhydric alcohol and aliphatic monocarboxylic acid (e.g., a partial ester of sorbitan). One of the above oiliness agents may be used alone or a combination of two or more thereof may be used.

[0034] A content of the oiliness agent is not particularly limited, but is preferably in a range from 0.01 mass% to 5 mass% of the total amount of the composition.

[0035] An additive for providing necessary characteristics as a lubricating oil composition may be further added to the present composition. Examples of the additive include an antioxidant, a rust inhibitor, an anticorrosive agent, and an antifoaming agent.

[0036] Examples of the rust inhibitor include a fatty acid, an alkenylsuccinic acid half ester, a fatty acid soap, an alkyl sulfonate, a fatty acid ester of polyhydric alcohol, a fatty acid amide, oxidized paraffin and an alkylpolyoxyethylene ether. A preferable content of the rust inhibitor is not particularly limited, but is in a range from 0.01 mass% to 3 mass% of the total amount of the composition.

[0037] Examples of the anticorrosive agent include a benzotriazole anticorrosive agent, a benzimidazole anticorrosive agent, a benzothiazole anticorrosive agent and a thiadiazole anticorrosive agent. A preferable content of the anticorrosive agent is not particularly limited, but is in a range from 0.01 mass% to 1 mass% of the total amount of the composition.

[0038] Examples of the antifoaming agent include a silicone compound and an ester compound. A preferable content of the antifoaming agent is not particularly limited, but is in a range from 1 mass ppm to 5000 mass ppm of the total amount of the composition.

[0039] The present composition preferably has a kinematic viscosity at 100 degrees C in a range from 13.5 mm^2/s to 18.5 mm^2/s, more preferably 14 mm^2/s to 16 mm^2/s. When the kinematic viscosity at 100 degrees C is 13.5 mm^2/s or more, the viscosity index can be effectively improved. On the other hand, when the kinematic viscosity at 100 degrees C exceeds 18.5 mm^2/s, the fuel efficiency may be deteriorated.

[0040] A kinematic viscosity at 40 degrees C of the composition is preferably 65 mm^2/s or less, more preferably 60 mm^2/s or less. When the kinematic viscosity at 40 degrees C is 65 mm^2/s or less, the fuel efficiency is excellent.

[0041] The viscosity index of the present composition is preferably 245 or more, more preferably 250 or more. When the viscosity index is 245 or more, the fuel efficiency at ordinary temperatures is improved by reduction of the agitation loss and the like.

[0042] In the present composition, a reduction ratio of the kinematic viscosity at 100 degrees C in a shear stability test (an ultrasonic shear test) is preferably 15% or less, more preferably 10% or less. When the reduction ratio of the kinematic viscosity at 100 degrees C is 15% or less, a fatigue lifetime of a gear, a bearing and the like can be prolonged, resulting in excellent reliability of a device to which the present composition is applied.

[0043] Since the present composition has a reduced viscosity at ordinary temperatures to reliably provide a favorable fuel efficiency and an excellent shear stability and can further reduce friction loss, the present composition is suitably used as a lubricating oil composition for a gear device that is usable in a manual transmission and a final reduction gear for automobiles, a step-up gear and a reducer for industrial machines, and the like.

Examples

[0044] Next, the invention will be further described in detail based on Examples, which by no means limit the invention. Properties (i.e., kinematic viscosities at 40 degrees C and 100 degrees C, a viscosity index, a flash point, shear stability, wear properties and appearance) of a lubricating oil composition (sample oil) in each Example were measured by the following method.

(1) Kinematic Viscosities at 40 degrees C and 100 degrees C

[0045] Kinematic viscosities at 40 degrees C and 100 degrees C (unit: mm^2/s) were measured according to a method described in JIS K2283.

(2) Viscosity Index

[0046] A viscosity index was measured according to a method described in JIS K2283.

(3) Flash Point:

[0047] A flash point was measured according to JIS K 2265. The flash point is preferably 150 degrees C or more in a practical use.

(4) Shear Stability (Ultrasonic Shear Stability Test)

[0048] A test was conducted according to JPI-5S-29-88 (A method, 60 minutes, 30 mL). A reduction ratio (%) of the kinematic viscosity was calculated based on the kinematic viscosity at 100 degrees C obtained after the test. The reduction ratio of the kinematic viscosity at 100 degrees C is preferably 15% or less in a practical use.

(5) Wear Properties (Wear of Synchronizer Ring)

[0049] After 100,000 cycles in a synchronizer tester under the following conditions, a wear length was measured. The wear length is defined by a change amount (unit: mm) of a gap between the synchronizer ring and the gear cone and is represented by a value obtained by subtracting a width of the gap before the test from a width of the gap after the test. The wear length is preferably 0.3 mm or less in a practical use.
Material for synchronizer ring (SNR): high-strength brass
Cone angle (θ) of SNR: 6.5 degrees
Effective radius of SNR: 26.5 mm
Material for gear: carbon steel
Revolution speed of gear: 1200 rpm
Press force of SNR: 400 N
Press time and down-time of SNR: press time for 0.5 seconds and down-time for 1 second
Oil temperature: 80 degrees C
Oil amount: oil was fed to reach a shaft center of each of a driving shaft and a pressing shaft (about 4 L).

(6) Appearance

[0050] After the sample oils were cooled at minus 5 degrees C for 24 hours, appearance of each of the sample oils was visually observed to check whether whitening and deposition were present or absent.
No whitening and deposition is defined as "favorable."

Examples 1 to 9 and Comparatives 1 to 9

[0051] Lubricating oil compositions (sample oils) shown in Tables 1 and 2 were prepared using the following base oils and additives. The properties of each of the sample oils were evaluated by the above-mentioned method. Results are shown in Tables 1 and 2.

Mineral oil-1: a highly purified mineral oil (kinematic viscosity at 100 degrees C: 0.87 mm^2/s)
Mineral oil-2: a highly purified mineral oil (kinematic viscosity at 100 degrees C: 1.5 mm^2/s, viscosity index: 83)
Mineral oil-3: a highly purified mineral oil (kinematic viscosity at 100 degrees C: 2.2 mm^2/s, viscosity index: 109)
Mineral oil-4: a highly purified mineral oil (kinematic viscosity at 100 degrees C: 2.7 mm^2/s, viscosity index: 114)
Mineral oil-5: a highly purified mineral oil (kinematic viscosity at 100 degrees C: 3.1 mm^2/s, viscosity index: 109)
Mineral oil-6: a highly purified mineral oil (kinematic viscosity at 100 degrees C: 4.1 mm^2/s, viscosity index: 131)
Synthetic oil-1: poly-α-olefin (kinematic viscosity at 100 degrees C: 1.8 mm^2/s, viscosity index: 128)
Synthetic oil-2: poly-α-olefin (kinematic viscosity at 100 degrees C: 3.9 mm^2/s, viscosity index: 120)
Synthetic oil-3: poly-α-olefin (kinematic viscosity at 100 degrees C: 5.9 mm^2/s, viscosity index: 132)
Ester A: diacid ester (kinematic viscosity at 100 degrees C: 4.3 mm^2/s, viscosity index: 139)
PMA-1: polymethacrylate ($Mw=1.7\times10^5$)
PMA-2: polymethacrylate ($Mw=5.5\times10^5$)
PMA-3: polymethacrylate ($Mw=3.2\times10^4$)

ZnDTP: dithiophosphate
Polybutenyl succinimide
Polysulfide
Sulfurized fat and oil phosphate amine salt
Partial ester of sorbitan
Ca sulfonate: total base number of 400 mgKOH/g
MoDTC: 4.1 mass% of Mo amount in the compound
Antifoaming agent: silicone antifoaming agent

Table 1

Table 2

				Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9
Blend Composition (mass%)	Base Oil	Mineral oil-1		—	—	—	44.25	—	—	36.25	—	—
		Mineral oil-2		—	—	—	—	46.75	—	—	—	—
		Mineral oil-3		—	54.25	47.07	—	—	—	—	—	—
		Mineral oil-4		—	—	—	—	—	46.84	—	—	—
		Mineral oil-5		—	—	—	—	—	—	—	—	—
		Mineral oil-6		—	—	—	—	—	—	10.00	—	—
		Synthetic oil-1		48.87	—	—	—	—	—	—	63.95	53.95
		Synthetic oil-2		—	—	—	—	—	—	—	—	—
		Synthetic oil-3		—	—	—	—	—	—	—	—	—
		Ester A		10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
	Additive	PMA-1		5.00	5.00	—	—	—	—	—	5.00	5.00
		PMA-2		—	—	—	—	—	—	—	—	—
		PMA-3		30.08	24.70	36.88	39.70	37.20	37.11	37.70	15.00	25.00
		ZnDTP		1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
		Succinimide		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sulfide		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Sulfurized fat and oil		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
		Phosphate amine salt		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Partial ester of sorbitan		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Ca Sulfonate		1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
		MoDTC		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
		Antifoaming agent		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	Total			100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Kinematic Viscosity at 100°C of base oil			mm^2/s	2.0	2.4	2.4	1.0	1.8	2.9	1.3	2.0	2.0
Evaluation Results	Kinematic Visocity(40°C)		mm^2/s	58.7	58.2	53.8	51.6	53.4	55.6	56.5	21.7	37.7
	Kinematic Visocity(100°C)		mm^2/s	14.5	14.1	14.1	14.2	14.1	14.3	14.1	6.2	10.1
	Viscosity Index		—	261	253	275	289	276	270	261	263	270
	Flash point(COC)		°C	172	174	162	98	138	168	116	160	166
	Shear Stability		%	11.1	10.5	2.6	1.8	2.8	3.8	1.9	9.7	10.2
	Wear of Synchronizer Ring		mm	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Appearance		—	favorable	favorable	favorable	favorable	favorable	favorable	favorable	favorable	favorable

Evaluation Results

[0052] As obvious from the results shown in Table 1, in the sample oils in Examples 1 to 9 (i.e., the lubricating oil composition of the invention), the viscosity at the ordinary

				Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Comp. 6	Comp. 7	Comp. 8	Comp. 9
Blend Composition (mass%)	Base Oil	Mineral oil-1		–	–	–	–	–	–	–	–	–
		Mineral oil-2		–	–	–	–	–	–	–	–	–
		Mineral oil-3		–	–	–	–	–	–	–	–	–
		Mineral oil-4		–	–	–	–	–	–	–	–	–
		Mineral oil-5		–	–	57.72	–	–	–	–	–	–
		Mineral oil-6		–	–	–	56.48	–	–	–	73.95	69.25
		Synthetic oil-1		–	–	–	–	63.95	71.10	55.87	–	–
		Synthetic oil-2		65.62	–	–	–	–	–	–	–	–
		Synthetic oil-3		–	60.22	–	–	–	–	–	–	–
		Ester A		–	10.00	10.00	10.00	10.00	10.00	–	10.00	10.00
	Additive	PMA-1		–	–	–	–	20.00	–	5.00	–	–
		PMA-2		–	–	–	–	–	12.85	–	–	–
		PMA-3		28.33	23.73	26.23	27.47	–	–	33.08	10.00	14.70
		ZnDTP		1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
		Succinimide		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sulfide		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Sulfurized fat and oil		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
		Phosphate amine salt		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Partial ester of sorbitan		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Ca Sulfonate		1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
		MoDTC		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
		Antifoaming agent		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	Total			100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Kinematic Viscosity at 100°C of base oil			mm^2/s	3.9	5.4	3.2	4.1	2.0	1.9	1.8	4.1	4.1
Evaluation Results	Kinematic Visocity(40°C)		mm^2/s	71.9	67.3	72.4	63.6	46.6	52.0	56.5	27.6	50.0
	Kinematic Visocity(100°C)		mm^2/s	14.7	14.2	14.1	14.1	14.4	14.1	14.5	6.2	10.1
	Viscosity Index		–	215	221	203	232	324	284	270	185	195
	Flash point(COC)		°C	170	230	184	210	162	162	168	204	206
	Shear Stability		%	2.9	3.2	2.5	2.9	26.9	37.3	12.2	1.8	2.2
	Wear of Synchronizer Ring		mm	0.1	0.1	0.1	0.1	0.6	0.6	0.1	0.1	0.1
	Appearance		–	favorable	favorable	favorable	favorable	favorable	favorable	whitened	favorable	favorable

temperatures is reduced to reliably provide a favorable fuel efficiency (65 degrees C or less of the viscosity at 40 degrees C). Moreover, the shear stability is also excellent. Further, since the wear resistance is also excellent, specifically, the synchronizer ring has less wear, it is found that operability of the synchronizer ring can be maintained for a long period.

[0053] On the other hand, as shown in Table 2, in the sample oils of Comparatives 1 to 9, since at least one of the kinematic viscosity at 100 degrees C of the base oil and the mass average molecular weight of the polymer (PMA) fall s out of the range defined in the invention, the sample oils of Comparatives 1 to 9 cannot solve the problem of the invention.

Claims

1. A lubricating oil composition comprising:

a first base oil having a kinematic viscosity at 100 degrees C in a range from 0.5 mm^2/s to 3.5 mm^2/s; and
a first poly(meth)acrylate having a mass average molecular weight in a range from 3×10^4 to 5×10^4.

2. The lubricant oil composition according to claim 1, further comprising:

an ester having a kinematic viscosity at 100 degrees C of 5 mm^2/s or less as a second base oil.

3. The lubricating oil composition according to claim 1 or 2, further comprising:

a second poly(meth)acrylate having a mass average molecular weight in a range from 1.4×10^5 to 2×10^5.

4. The lubricating oil composition according to any one of claims 1 to 3, further comprising:

a molybdenum compound.

5. The lubricating oil composition according to any one of claims 1 to 4, further comprising:

at least one of a detergent dispersant, an extreme pressure agent, and an oiliness agent.

6. The lubricating oil composition according to any one of claims 1 to 5, wherein
the lubricating oil composition has the kinematic viscosity at 100 degrees C in a range from13.5 mm^2/s to 18.5 mm^2/s and a kinematic viscosity at 40 degrees C of 65 mm^2/s or less.

7. The lubricating oil composition according to any one of claims 1 to 6, wherein the lubricating oil composition has a viscosity index of 245 or more.

8. The lubricating oil composition according to any one of claims 1 to 7, wherein
the lubricating oil composition has 15% or less of a reduction ratio of the kinematic viscosity at 100 degrees C in a shear stability test that is an ultrasonic shear test.

9. The lubricating oil composition according to any one of claims 1 to 8, wherein the lubricating oil composition is used for a manual transmission.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/056639

A. CLASSIFICATION OF SUBJECT MATTER
C10M145/14(2006.01)i, *C10M105/32*(2006.01)n, *C10M169/04*(2006.01)n, *C10N10/12*(2006.01)n, *C10N30/00*(2006.01)n, *C10N40/04*(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)
C10M145/14, C10M105/32, C10M169/04, C10N10/12, C10N30/00, C10N40/04

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

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Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2012-201808 A (JX Nippon Oil & Energy Corp.), 22 October 2012 (22.10.2012), claims; examples; paragraph [0079] & WO 2012/132054 A1	1,3-9 2,3
X Y	WO 2004/074414 A1 (Nippon Oil Corp.), 02 September 2004 (02.09.2004), claims; examples & JP 2004-262979 A & JP 2004-262980 A & US 2006/0135378 A1 & EP 1598412 A1	1,4-9 2,3
X Y	JP 2004-155924 A (Tonen General Sekiyu Kabushiki Kaisha), 03 June 2004 (03.06.2004), claims; examples (Family: none)	1,4-9 2,3

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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