

SPECIFICATION

HYDRAULIC OIL COMPOSITION

5 Technical Field

[0001]

The present invention is related to a hydraulic oil composition, and more particularly, to a hydraulic oil composition which has good energy saving properties, thermal stability (sludge resistance), wear resistance, seizure resistance (scuffing resistance), demulsibility
10 properties, friction-reducing properties of sliding parts and the like and is suitably used in the hydraulic machine field, machine tool field, industrial machine field and the like.

Background Art

[0002]

A hydraulic oil is a power transmission fluid used for the actuation of power
15 transmission, force control, shock absorption and the like in a hydraulic system including hydraulic machinery, equipment and the like and also fulfils the function of lubricating sliding parts.

There exist metal to metal or metal to rubber (resin) and the like sliding parts in a pump, a control valve, a hydraulic cylinder and the like in a hydraulic circuit. The hydraulic
20 oil used in such hydraulic circuit is required to have good friction characteristics such as wear resistance, seizure resistance and friction-reducing properties in these sliding parts.

In addition, in recent years, as a hydraulic actuation system has been increasingly sophisticated, there have been many cases where the flow rate and direction of the hydraulic system is controlled by a spool valve in order to perform precise control at high speed and a

servo valve is disposed. Since the performance of such spool valve and servo valve is significantly decreased if sludge is generated in the hydraulic oil, there has been strongly demanded a hydraulic oil to be used which has excellent friction characteristics and at the same time excellent sludge resistance which may prevent the generation of sludge.

5 Further, from the viewpoint of energy saving, there has been demanded the sophistication of the hydraulic oil such as reduction of loss energy and prevention of oil temperature rise by reducing the resistance in the sliding parts.

[0003]

Conventionally, Zinc dithiophosphate (ZnDTP) had been widely used as an antiwear
10 agent of a hydraulic oil. However, ZnDTP causes the generation of sludge and may not be used by blending with the hydraulic oil for a long period of time. In addition, the antiwear effect of ZnDTP is caused by the formation of a hard coated film such as iron phosphate onto a metal surface. However, since the friction coefficient of the sliding parts is increased by the formation of the coated film, it may not be said that the use of ZnDTP is preferable from
15 the viewpoint of energy saving.

Consequently, there has been studied a hydraulic oil using a so-called non-zinc based antiwear agent wherein the hydraulic oil does not contain ZnDTP.

For example, there has been proposed a hydraulic oil in which an aromatic phosphate ester, a phosphite ester and its amine salt, a thiophosphate and a β -dithiophosphorylated
20 propionic acid compound are blended as an antiwear agent in place of ZnDTP (for example, refer to Patent Documents 1, 2 and 3).

However, it may not be said that these hydraulic oils fully satisfy friction characteristics such as sludge resistance (sludge preventing properties) and wear resistance and still leave room for improvement as a hydraulic oil which may meet the needs of

sophistication and energy saving of the hydraulic actuation system.

[0004]

In addition, there is disclosed a composition (for example, refer to Patent Document 4) in which an antioxidant, a phosphorus and/or sulfur based compound and N-oleylsarcosine are used in combination in place of ZnDTP, and further, a composition (for example, refer to Patent Document 5) comprising, in combination, a phosphorus-containing carboxylic acid compound and a dispersion type viscosity index improver.

However, it may not be said that these hydraulic oils sufficiently have friction characteristics such as sludge resistance (sludge preventing properties) and wear resistance.

Accordingly, there is not yet found a hydraulic oil satisfying in a balanced manner energy saving properties, thermal stability (sludge resistance), wear resistance, seizure resistance (scuffing resistance), demulsibility properties, friction-reducing properties of sliding parts and the like, which are demanded of the hydraulic oil.

[0005]

Patent Document 1: Japanese Patent Laid-Open Publication No. H10-67993

Patent Document 2: Japanese Patent Laid-Open Publication No. H11-217577

Patent Document 3: Japanese Patent Laid-Open Publication No. 2002-265971

Patent Document 4: Japanese Patent Laid-Open Publication No. 2002-129180

Patent Document 5: Japanese Patent Laid-Open Publication No. 2005-307203

Disclosure of the Invention

Problems to be Solved by the Invention

[0006]

Under these conditions, the object of the present invention is to provide a hydraulic oil composition satisfying in a balanced manner energy saving properties, thermal stability

(sludge resistance), wear resistance, seizure resistance (scuffing resistance), demulsibility properties, friction-reducing properties of sliding parts and the like, which are demanded of the hydraulic oil.

Means for Solving the Problems

5 [0007]

As a result of earnest studies to develop a hydraulic oil composition satisfying the required performance for the hydraulic oil in a balanced manner, the present inventors found that the objective of the present invention may be achieved by blending a base oil having specific properties with a polymethacrylate-based viscosity index improver having a
10 molecular weight in a specific range, an acid amide compound, a specific phosphate ester based compound and a specific lubricity improver respectively at a predetermined ratio. The present invention has been completed based on such findings.

In other words, the present invention provides

[0008]

15 [1] a hydraulic oil composition comprising blending

a base oil having a sulfur content of less than 0.03% by mass, a content of saturated component of not less than 90% by mass, a viscosity index of not less than 80 and an absolute viscosity at 40 °C of 1 to 1000 mPa · s with

(A) 1 to 20% by mass of a polymethacrylate-based viscosity index improver having
20 an weight average molecular weight of 10000 to 50000,

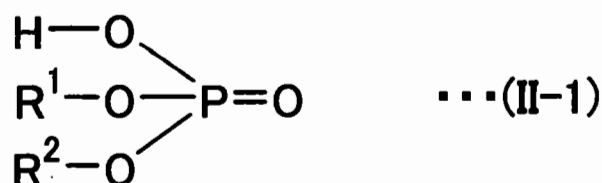
(B) 0.005 to 5% by mass of an acid amide compound,

(C) 0.005 to 5% by mass of an acid phosphate ester compound (c-1)

[0009]

represented by the following general formula (II-1):

[Chemical Formula 1]



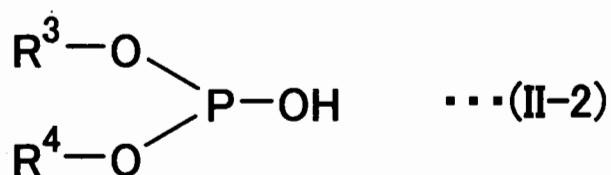
(In the formula, R^1 represents a hydrogen atom or a hydrocarbon group having 1 to 18 carbon atoms and R^2 represents a hydrocarbon group having 1 to 18 carbon atoms.) and/or

5 an acid phosphite ester compound (c-2)

[0010]

represented by the following general formula (II-2):

[Chemical Formula 2]



10 (In the formula, R^3 represents a hydrogen atom or a hydrocarbon group having 1 to 18 carbon atoms and R^4 represents a hydrocarbon group having 1 to 18 carbon atoms.), and

(D) 0.005 to 5% by mass of at least one kind selected from a polyhydric alcohol ester, an alkanolamine, an olefin sulfide and a thiocarbamate compound, and further

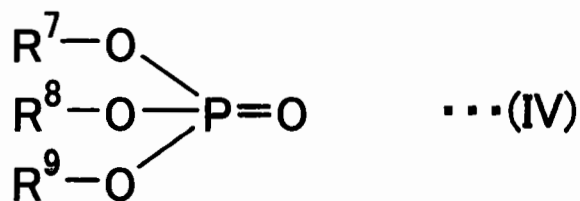
[2] a hydraulic oil composition described in the above [1] comprising blending 0.005
15 to 5% by mass of at least one kind selected from (E) an amine salt of an acid phosphate ester compound and

[0011]

a phosphate triester compound represented by the following general formula (IV):

[Chemical Formula 3]

20



(In the formula, R⁷ to R⁹ each independently represent a hydrocarbon group having 1 to 18 carbon atoms).

Effect of the Invention

5 [0012]

According to the present invention, there may be provided a hydraulic oil composition which has excellent energy saving properties, thermal stability (sludge resistance), wear resistance, seizure resistance (scuffing resistance), demulsibility properties, friction-reducing properties of sliding parts and the like and is suitably used in the hydraulic machine field, machine tool field, industrial machine field and the like.

Best Mode for Carrying Out the Invention

[0013]

The hydraulic oil composition of the present invention is a composition comprising blending a base oil, (A) a polymethacrylate based viscosity index improver, (B) an acid amide compound, (C) an acid phosphate ester compound (c-1) and/or an acid phosphite ester compound (c-2) and (D) a lubricity improver.

The base oil used in the hydraulic oil composition of the present invention is required to have a sulfur content of less than 0.03% by mass, a content of saturated component of not less than 90% by mass, a viscosity index of not less than 80 and an absolute viscosity at 40 °C of 1 to 1000 mPa · s.

If the base oil has a sulfur content of not less than 0.03% by mass and a content of saturated component of less than 90% by mass, the effect of the present invention is not

sufficiently exerted because of the poor oxidation stability, the increase of acid value and the generation of sludge, together with the increased corrosion against a nonferrous metal. The sulfur content is preferably not more than 0.02% by mass and more preferably not more than 0.01% by mass. In addition, the content of saturated component is preferably not less than 95% by mass and more preferably not less than 98% by mass.

Incidentally, the sulfur content is a value measured in accordance with JIS K 2541 and the content of saturated component is a value measured in accordance with ASTM D 2007.

In addition, if the base oil has a viscosity index of less than 80, the viscosity decreases at high temperatures and the lubricating performance is likely to decrease. On the other hand, the viscosity increases at low temperatures and the suction failure of a pump may occur. The viscosity index is preferably not less than 100 and more preferably not less than 120 from the viewpoint of widening the usable temperature range from low temperatures to high temperatures.

Incidentally, the viscosity index is a value measured in accordance with "Testing Methods for Kinematic Viscosity and Calculating Method for Viscosity Index of Crude Oil and Petroleum Products" described in JIS K 2283.

[0014]

If the base oil has an absolute viscosity at 40 °C of less than 1 mPa · s, the lubricating performance is insufficient, abnormal wear or seizure is likely to occur and the risk of fire is high. On the other hand, if the base oil has an absolute viscosity exceeding 1000 mPa · s, the viscous resistance is increased at low temperatures and the suction to the pump is interrupted, thereby possibly causing malfunction of machines. From the viewpoint of the friction characteristics, risk of fire and the viscous resistance at low temperatures, the base oil has an

absolute viscosity at 40 °C of 3 to 500 mPa · s, more preferably 5 to 300 mPa · s and especially preferably 10 to 150 mPa · s.

As the base oil, there may be used either a mineral oil or a synthetic oil so long as it has the above properties. There are no particular limitations on the type of the mineral oil and the synthetic oil and others. The mineral oil includes, for example, a paraffin based mineral oil, an intermediate base mineral oil, a naphthene based mineral oil or the like which is obtained by a usual purification method such as solvent purification and hydrogenation purification.

In addition, the synthetic oil includes, for example, polybutene, polyolefin (α -olefin(co)polymer), various esters (for example, polyolester, dibasic acid ester, phosphate ester and the like), various ethers (for example, polyphenyl ether and the like) and further an isomerized product of either slack wax or GTL WAX, and the like.

In the present invention, the base oils may be used singly or in combination of two or more kinds thereof. In addition, the above synthetic oils may be used singly or in combination of two or more kinds thereof. Further, one or more kinds of the mineral oils and one or more kinds of the synthetic oils may be used in combination.

[0015]

The polymethacrylate-based viscosity index improver of the component (A) in the hydraulic oil composition of the present invention has a weight average molecular weight in the range of 10000 to 50000, and such polymethacrylate-based viscosity index improver includes, for example, a polymethacrylate, a dispersion type polymethacrylate and the like. If the polymethacrylate-based viscosity index improver has a weight average molecular weight of less than 10000, the viscosity index improving effect may not be sufficiently exerted. If the polymethacrylate-based viscosity index improver has a weight average

molecular weight exceeding 50000, the polymer is cut when in use and thus the viscosity index improving effect may not be sufficiently exerted. The polymethacrylate-based viscosity index improver preferably has a weight average molecular weight in the range of 20000 to 40000.

5 Incidentally, the weight average molecular weight is a value relative to polystyrene measured by a gel permeation chromatography (GPC) method.

In the present invention, any dispersion type polymethacrylate may be used without any particular limitation and includes, for example, a copolymer of methacrylate with a nitrogen-containing monomer having an ethylenic unsaturated bond.

10 The nitrogen-containing monomer having an ethylenic unsaturated bond includes dimethylaminomethylmethacrylate, diethylaminomethylmethacrylate, dimethylaminoethylmethacrylate, diethylaminoethylmethacrylate, 2-methyl-5-vinylpyridine, morpholinomethylmethacrylate, morpholinoethylmethacrylate, N-vinylpyrrolidone and a mixture thereof.

15 [0016]

The copolymerization ratio of methacrylate to the nitrogen-containing monomer having an ethylenic unsaturated bond is preferably 80:20 to 95:5 by mass.

In the hydraulic oil composition of the present invention, the polymethacrylate-based viscosity index improvers of the component (A) may be used singly or in combination of two or more kinds thereof. In addition, the addition amount is selected in the range of 1 to 20 % by mass based on the total amount of the composition. If the addition amount is less than 1% by mass, the viscosity index improving effect may not be sufficiently exerted, while if the addition amount exceeds 20% by mass, an improvement in the effect expected from the added amount is not observed.

The addition amount of the component (A) is preferably 1 to 15% by mass and more preferably 2 to 10% by mass.

[0017]

The acid amide compound of the component (B) in the hydraulic oil composition of the present invention is preferably a condensation reaction product of a fatty acid and a polyalkylene polyamine and includes, for example, a condensation reaction product of a fatty acid having 8 to 24 carbon atoms and a polyethylene polyamine represented by the following general formula (I)



(In the formula, n represents a number of 2 to 6 in average.)

[0018]

The fatty acid having 8 to 24 carbon atoms includes a linear or branched, saturated or unsaturated fatty acid and includes, for example, a linear saturated and linear unsaturated fatty acid such as octane acid, nonane acid, decane acid, undecane acid, dodecane acid, tetradecane acid, hexadecane acid, octadecane acid (stearic acid), hydroxyoctadecane acid, icosanoic acid, heneicosanoic acid, docosanoic acid, tricosanoic acid, tetracosanoic acid, octenoic acid, decene acid, dodecene acid, tetradecene acid, hexadecene acid, octadecene acid (oleic acid), nonadecene acid, icosenoic acid, heneicosenoic acid, docosenoic acid, tricosenoic acid, tetracosenoic acid and the like, as well as branched fatty acids corresponding thereto.

Among these, preferable is isostearic acid which is a branched fatty acid having the total number of carbon atoms of 18.

[0019]

Meanwhile, the specific examples of the polyethylenepolyamine represented by the general formula (I) include, for example, ethylene diamine, diethylene triamine, triethylene

tetramine, tetraethylene pentamine, pentaethylene hexamine, hexaethylene heptamine, and the like.

[0020]

The acid amide compound (B) used in the hydraulic oil composition of the present invention is preferably a reaction product obtained by using the fatty acid and polyalkylene polyamine as reaction raw materials. The reaction product may be obtained by condensation reaction of a fatty acid and a polyalkylene polyamine by a known method. For example, the fatty acid and polyalkylene polyamine are reacted at a reaction temperature of 100 to 150 °C for a reaction time of 1 to 5 hours. In this case, the ratio of the fatty acid to the polyalkylene polyamine used as reaction raw materials is arbitrary, but it is preferable that the polyalkylene polyamine is slightly in excess.

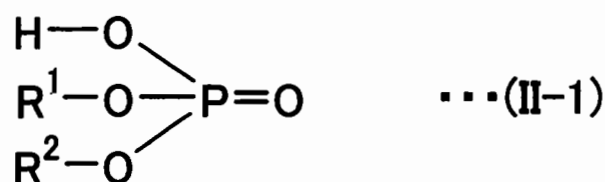
In the present invention, the acid amide compounds of these components (B) may be used singly or in combination of two or more kinds thereof. The addition amount of the components (B) is in the range of 0.005 to 5% by mass, preferably 0.01 to 5% by mass and more preferably 0.02 to 3% by mass, based on the total amount of the composition.

[0021]

In the hydraulic oil composition of the present invention, among the components (C), the acid phosphate ester compound is a compound represented by the following general formula (II-1).

[0022]

[Chemical Formula 4]



[0023]

In the general formula (II-1), R^1 is a hydrogen atom or a hydrocarbon group having 1 to 18 carbon atoms, and R^2 is a hydrocarbon group having 1 to 18 carbon atoms. The hydrocarbon group having 1 to 18 carbon atoms includes an alkyl group having 1 to 18 carbon atoms, an alkenyl group having 2 to 18 carbon atoms, an aryl group having 6 to 18 carbon atoms, an aralkyl group having 7 to 18 carbon atoms and the like. The alkyl group and alkenyl group may be linear, branched or cyclic, and the specific example includes methyl group, ethyl group, n-propyl group, isopropyl group, n-butyl group, isobutyl group, sec-butyl group, tert-butyl group, various pentyl groups, various hexyl groups, various octyl groups, various decyl groups, various dodecyl groups, various tetradecyl groups, various hexadecyl groups, various octadecyl groups, cyclopentyl group, cyclohexyl group, allyl group, propenyl group, various butenyl groups, various hexenyl groups, various octenyl groups, various decenyl groups, various dodecenyl groups, various tetradecenyl groups, various hexadecenyl groups, various octadecenyl groups, cyclopentenyl group, cyclohexenyl group and the like.

The aryl group having 6 to 18 carbon atoms includes, for example, phenyl group, tryl group, xylyl group, naphthyl group and the like, and the aralkyl group having 7 to 18 carbon atoms includes, for example, benzyl group, phenethyl group, naphthylmethyl group, methylbenzyl group, methylphenethyl group, methylnaphthylmethyl group and the like.

The total number of carbon atoms of R^1 and R^2 is preferably in the range of 3 to 36, and accordingly, R^1 and R^2 are each selected as appropriate from the groups so that the total number of carbon atoms is in the range of 3 to 36.

[0024]

The acid phosphate ester compound represented by the general formula (II-1) is an acid phosphate monoester or acid phosphate diester.

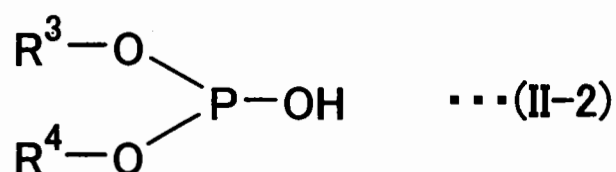
The acid phosphate mono- or diester includes, for example, mono(di)-n-propylacid phosphate, mono(di)-n-butylacid phosphate, mono(di)-2-ethylhexylacid phosphate, mono(di)-decylacid phosphate, mono(di)-laurylacid phosphate, mono(di)-tridecylacid phosphate, mono(di)-myristylacid phosphate, mono(di)-palmitylacid phosphate, mono(di)-stearylacid phosphate, mono(di)-oleylacid phosphate and the like.

[0025]

Among the components (C), the acid phosphite ester compound of (c-2) is a compound represented by the following general formula (II-2).

[0026]

[Chemical Formula 5]



In the general formula (II-2), R^3 is the same as R^1 in the general formula (II-1) and R^4 in the general formula (II-2) is the same as R^2 in the general formula (II-1). In addition, the total number of carbon atoms of R^3 and R^4 is the same in the case of the acid phosphate ester compound in the general formula (II-1).

The acid phosphate ester compound of the general formula (II-2) includes, for example, mono(di)-2-ethylhexylhydrogen phosphite, mono(di)-decylhydrogen phosphite, mono(di)-dodecylhydrogen phosphite (mono(di)-laurylhydrogen phosphite), mono(di)-octadecylhydrogen phosphite (mono(di)-stearylhydrogen phosphite), mono(di)-9-octadecenylhydrogen phosphite (mono(di)-oleylhydrogen phosphite), mono(di)-phenylhydrogen phosphite and the like.

[0027]

In the present invention, as these components (C), the acid phosphate ester compounds of (c-1) may be used singly or in combination of two or more kinds thereof. In addition, the acid phosphite ester compounds of (c-2) may be used singly or in combination of two or more kinds thereof. Further, there may be used, in combination, one or more kinds of the acid phosphate ester compounds of (c-1) and one or more kinds of the acid phosphite ester compounds of (c-2). The addition amount of the components (C) is 0.005 to 5% by mass, preferably 0.01 to 3% by mass and more preferably 0.02 to 2% by mass, based on the total amount of the composition. In addition, in the relationship with the addition amount of the components (B), the components (C) are added so that the mass ratio of (B) to (C) is preferably 0.1 to 4.0 and more preferably 0.5 to 3.0. If the mass ratio of (B) to (C) is 0.1 to 4.0, the chattering (stick slip) phenomenon between the cylinder and rubber (resin) may be prevented.

[0028]

In the hydraulic oil composition of the present invention, as the lubricity improver of the component (D), there may be used at least one kind selected from a polyhydric alcohol partial ester, an alkanolamine, an olefin sulfide and a dithiocarbamate compound.

In the polyhydric alcohol partial ester of the component (D), the polyhydric alcohol used as a raw material preferably includes, but not particularly limited to, aliphatic polyols. The aliphatic polyols include, for example, a dihydric alcohol such as ethylene glycol, diethylene glycol, triethylene glycol, propylene glycol, trimethylene glycol, tetramethylene glycol and neopentyl glycol; a trihydric alcohol such as glycerin, trimethylolethane and trimethylolpropane; and a tetrahydric or higher alcohol such as diglycerin, triglycerin, pentaerythritol, dipentaerythritol, mannitol and sorbitol.

The number of the ester bonds in the partial ester is not particularly limited if at least

one hydroxyl group is present. The hydrocarbyl group constituting the ester bond is preferably an alkyl group or alkenyl group having 6 to 20 carbon atoms and includes, for example, various hexyl groups, octyl groups, decyl groups, dodecyl groups, tetradecyl groups, hexadecyl groups, octadecyl groups, hexenyl groups, octenyl groups, decenyl groups, dodecenyl groups, tetradecenyl groups, hexadecenyl groups and octadecenyl groups.

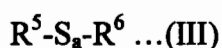
[0029]

The specific examples of the partial esters of the polyhydric alcohol include, but not limited to, neopentylglycol monolaurate, neopentylglycol monomyristate, neopentylglycol monopalmitate, neopentylglycol monostearate, neopentylglycol monoisostearate, trimethylolpropane mono- or dilaurate, trimethylolpropane mono- or dimyristate, trimethylolpropane mono- or dipalmitate, trimethylolpropane mono- or distearate, trimethylolpropane mono- or diisostearate, glycerin mono- or dilaurate, glycerin mono- or distearate, glycerin mono- or diisostearate and the like.

The partial esters of the polyhydric alcohol of the components (D) may be used singly or in combination of two or more kinds thereof.

[0030]

The olefin sulfide as the lubricity improver of the component (D) includes, for example, a compound represented by the following general formula (III)



(In the formula, R^5 represents an alkenyl group having 3 to 20 carbon atoms, R^6 represents an alkyl group or alkenyl group having 3 to 20 carbon atoms, and a represents an integer of 1 to 8.) The compound may be obtained by reacting an olefin having 3 to 20 carbon atoms or its dimer to tetramer with a sulfurizing agent such as sulfur, sulfur chloride or the like. As the olefin, preferable are propylene, isobutene, diisobutene and the like.

In the present invention, the olefin sulfides of the component (D) may be used singly or in combination of two or more kinds thereof.

[0031]

The alkanolamine in the lubricity improver of the component (D) includes, for
5 example, a di-substituted amine or a tri-substituted amine having 4 to 60 carbon atoms such as
stearyl-monoethanolamine, decyl-monoethanolamine, hexyl-monopropanolamine,
benzyl-monoethanolamine, phenyl-monoethanolamine, tolyl-monopropanolamine,
diolel-monoethanolamine, dilauryl-monopropanolamine, dioctyl-monoethanolamine,
dihexyl-monopropanolamine, dibutyl-monopropanolamine, oleyl-diethanolamine,
10 stearyl-dipropanolamine, lauryl-diethanolamine, octyl-dipropanolamine, butyl-diethanolamine,
benzyl-diethanolamine, phenyl-diethanolamine, tolyl-dipropanolamine, xylyl-diethanolamine,
triethanolamine and tripropanolamine.

These alkanolamines may be used singly or in combination of two or more kinds thereof.

15 [0032]

The thiocarbamate compound in the lubricity improver of the component (D) preferably includes, for example, methylenebisdibutyl dithiocarbamate, methylenebisdioctyl dithiocarbamate and methylenebistridecyl dithiocarbamate.

These thiocarbamate compounds may be used singly or in combination of two or
20 more kinds thereof.

[0033]

In the hydraulic oil composition of the present invention, as the lubricity improver of the component (D), polyhydric alcohol partial esters, alkanolamines, olefin sulfides and dithiocarbamate compounds may be used alone or in combination of two or more of them.

In addition, the addition amount of the component (D) is selected in the range of 0.005 to 5% by mass based on the total amount of the composition. If the addition amount is less than 0.005% by mass, the effect of the friction reduction at sliding parts of the hydraulic pump and the friction reduction and wear resistance improvement between the rubber material and metal at the actuator and the like mounted in the hydraulic system is unlikely to be exerted sufficiently, while if the addition amount exceeds 5% by mass, the generation of sludge is increased and the demulsibility properties are deteriorated. The addition amount of the lubricity improver of the component (D) is preferably 0.01 to 5% by mass, more preferably 0.03 to 3% by mass and further more preferably 0.05 to 2% by mass.

10 [0034]

In the hydraulic oil composition of the present invention, as the lubricity enhancer (E), there may be further used at least one kind selected from an amine salt of an acidic phosphate ester and a phosphate triester compound where appropriate. By so doing, the effect of the lubricity improver may be further enhanced.

15 [0035]

As the amine salt of the acid phosphate ester, there may be used an amine salt of the acid phosphate ester represented by the general formula (II-1). As an amine compound constituting the amine salt, there may be used a mono-substituted amine, di-substituted amine and tri-substituted amine having 4 to 60 carbon atoms.

20 Examples of the mono-substituted amine include butylamine, pentylamine, hexylamine, cyclohexylamine, octylamine, laurylamine, stearylamine, oleylamine, benzylamine and the like. Examples of the di-substituted amine include dibutylamine, dipentylamine, dihexylamine, dicyclohexylamine, dioctylamine, dilaurylamine, distearylamine, dioleylamine, dibenzylamine and the like. Examples of the tri-substituted

amine include tributylamine, tripentylamine, trihexylamine, tricyclohexylamine, trioctylamine, trilaurylamine, tristearylamine, trioleylamine, tribenzylamine and the like, and further an alkanol amine, for example, stearyl-monoethanolamine, decyl-monoethanolamine, hexyl-monopropanolamine, benzyl-monoethanolamine, phenyl-monoethanolamine, 5 tolyl-monopropanolamine, diolel-monoethanolamine, dilauryl-monopropanolamine, dioctyl-monoethanolamine, dihexyl-monopropanolamine, dibutyl-monopropanolamine, oleyl-diethanolamine, stearyl-dipropanolamine, lauryl-diethanolamine, octyl-dipropanolamine, butyl-diethanolamine, benzyl-diethanolamine, phenyl-diethanolamine, tolyl-dipropanolamine, xylyl-diethanolamine, triethanolamine and tripropanolamine and the like.

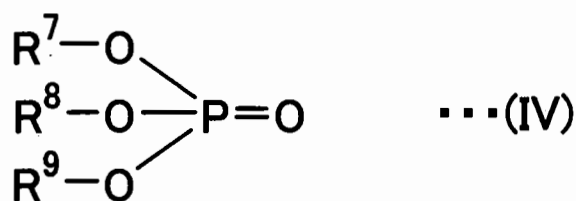
10 These amine compounds may be used singly or in combination of two or more kinds thereof.

[0036]

The phosphate triester compound is a compound represented by the following general formula (IV):

15 [0037]

[Chemical Formula 6]



[0038]

(In the formula, R⁷ to R⁹ are the same as R² in the general formula (II).) and includes a triaryl phosphate, a trialkyl phosphate, a trialkylaryl phosphate, a triarylalkyl phosphate and a 20 trialkenyl phosphate, for example, triphenyl phosphate, tricresyl phosphate, benzyldiphenyl phosphate, ethyldiphenyl phosphate, tributyl phosphate, ethyldibutyl phosphate,

cresyldiphenyl phosphate, dicresylphenyl phosphate, ethylphenyldiphenyl phosphate, di(ethylphenyl)phenyl phosphate, propylphenyldiphenyl phosphate, di(propylphenyl)phenyl phosphate, triethylphenyl phosphate, tripropylphenyl phosphate, butylphenyldiphenyl phosphate, di(butylphenyl)phenyl phosphate, tributylphenyl phosphate, trihexyl phosphate, tri(2-ethylhexyl)phosphate, tridecyl phosphate, trilauryl phosphate, trimyristyl phosphate, tripalmityl phosphate, tristearyl phosphate, trioleyl phosphate and the like.

[0039]

As the lubricity enhancer of (E) which may be added when needed in the present invention, the amine salts of the acid phosphate ester may be used singly or in combination of two or more kinds thereof. In addition, the phosphate ester compounds may be used singly or in combination of two or more kinds thereof. Furthermore, there may be used in combination one or more kinds of amine salts of an acid phosphate ester and one or more kinds of phosphate triester compounds. The addition amount of the component (E) is selected in the range of 0.005 to 5% by mass, preferably 0.01 to 5% by mass and more preferably 0.02 to 2% by mass, based on the total amount of the composition.

[0040]

In the hydraulic oil composition of the present invention, a detergent dispersant may be further added, if necessary.

As the detergent dispersant, there may be used an ashless detergent dispersant and/or a metal-based detergent dispersant.

Here, the ashless detergent dispersant includes, for example, succinimide, boron-containing imide succinates, benzyl amines, boron-containing benzyl amines and the like.

The metal-based detergent dispersant includes, for example, neutral, basic or

superbasic metal sulfonates, metal phenates, metal salicylates, metal phosphonates and the like. These ashless detergent dispersants and metal-based detergent dispersants may be used singly or in combination of two or more kinds thereof. The detergent dispersant is typically used in an amount of approximately 0.01 to 1% by mass based on the total amount of the composition.

[0041]

To the hydraulic oil composition of the present invention, there may added an antioxidant, a rust-preventive agent, a metal deactivator, a pour-point depressant, an antifoaming agent, a demulsifying agent and the like, if necessary, so long as the objective of the present invention is not impaired.

As the antioxidant, there may be preferably used a phenol-based antioxidant and an amine-based antioxidant.

As the phenol-based antioxidant, among known phenol-based antioxidants which have been conventionally used as an antioxidant for lubricating oils, any phenol-based antioxidant may be accordingly selected and used without any particular limitation. The phenol-based antioxidant includes, for example, monocyclic phenols such as 2,6-di-tert-butyl-4-methylphenol, 2,6-di-tert-butyl-4-ethylphenol, 2,4,6-tri-tert-butylphenol, 2,6-di-tert-butyl-4-hydroxymethylphenol, 2,6-di-tert-butylphenol, 2,4-dimethyl-6-tert-butylphenol, 2,6-di-tert-butyl-4-(N,N-dimethylaminomethyl)phenol, 2,6-di-tert-amyl-4-methylphenol, n-octadecyl-3-(4-hydroxy-3,5-di-tert-butylphenyl)propionate and the like; and polycyclic phenols such as 4,4'-methylenebis(2,6-di-tert-butylphenol), 4,4'-isopropylidenebis(2,6-di-tert-butylphenol), 2,2'-methylenebis(4-methyl-6-tert-butylphenol), 4,4'-bis(2,6-di-tert-butylphenol),

4,4'-bis(2-methyl-6-tert-butylphenol), 2,2'-methylenebis(4-ethyl-6-tert-butylphenol),
4,4'-butylidenebis(3-methyl-6-tert-butylphenol), 2,2'-thiobis(4-methyl-6-tert-butylphenol),
4,4'-thiobis(3-methyl-6-tert-butylphenol) and the like. Among these, monocyclic phenols
are preferred from the viewpoint of the effect.

5 [0042]

As the amine-based antioxidant, among known amine-based antioxidants which have
been conventionally used as an antioxidant for lubricating oils, any amine-based antioxidant
may be accordingly selected and used without any particular limitation. The amine-based
antioxidant includes, for example, a diphenylamine-based antioxidant, specifically an
10 alkylated diphenyl amine having an alkyl group having 3 to 20 carbon atoms such as
diphenylamine, monooctyldiphenylamine, monononyldiphenylamine,
4,4'-dibutyldiphenylamine, 4,4'-dihexyldiphenylamine, 4,4'-dioctyldiphenylamine,
4,4'-dinonyldiphenylamine, tetrabutyldiphenylamine, tetrahexyldiphenylamine,
tetraoctyldiphenylamine, tetranonyldiphenylamine and the like; and a naphthylamine based
15 antioxidant, specifically an alkyl-substituted phenyl- α -naphthylamine having 3 to 20 carbon
atoms including α -naphthylamine, phenyl- α -naphthylamine, butylphenyl- α -naphthylamine,
hexylphenyl- α -naphthylamine, octylphenyl- α -naphthylamine, nonylphenyl- α -naphthylamine
and the like. Among these, the diphenyl amine based antioxidant is more preferable to the
naphthyl amine based antioxidant from the viewpoint of the effect, and preferable is an
20 alkylated diphenylamine having an alkyl group having 3 to 20 carbon atoms and especially
preferable is 4,4'-di(C₃ to C₂₀ alkyl)diphenylamine.

[0043]

In the present invention, the phenol-based antioxidants may be used singly or in
combination of two or more kinds thereof. In addition, the amine-based antioxidants may be

used singly or in combination of two or more kinds thereof. Further, there may be used in combination one or more kinds of phenol-based antioxidants and one or more kinds of amine-based antioxidants.

In the present invention, the addition amount of the antioxidants is typically 0.05 to 2.0% by mass and preferably 0.1 to 1% by mass based on the total amount of the composition, from the viewpoint of the oxidation stability and other properties.

[0044]

The rust-preventive agent includes a metal sulfonate, a succinate ester and the like. The addition amount of these rust-preventive agents is typically approximately 0.01 to 5% by mass and preferably 0.03 to 1% by mass based on the total amount of the composition, from the viewpoint of the addition effect and other properties.

The metal deactivator includes benzotriazole, thiadiazole and the like. The addition amount of these metal deactivators is typically 0.005 to 1% by mass and preferably 0.007 to 0.5% by mass based on the total amount of the composition, from the viewpoint of the addition effect and other properties.

The pour-point depressant includes a polymethacrylate having a weight average molecular weight of approximately 50000 to 150000. The addition amount of the pour-point depressants is typically 0.1 to 5% by mass and preferably 0.2 to 2% by mass based on the total amount of the composition, from the viewpoint of the addition effect and other properties.

[0045]

The antifoaming agent preferably includes a polymer silicone based antifoaming agent and antifoaming properties are effectively exerted by adding the polymer silicone based antifoaming agent.

The polymer silicone based antifoaming agent includes, for example, an organopolysiloxane and especially suitable is a fluorine-containing organopolysiloxane such as trifluoropropylmethyl silicone oil. The polymer silicone based antifoaming agent is added preferably in the amount of approximately 0.0001 to 0.5% by mass, more preferably 5 0.0005 to 0.3% by mass, based on the total amount of the composition, from the viewpoint of the balance between the antifoaming effect and economic efficiency.

The Demulsifying Agent includes a conventionally known one, for example, an anionic surfactant such as a sulfate ester salt of castor oil and a petroleum sulfonate salt, a cationic surfactant such as a quaternary ammonium salt and an imidazoline type and further a 10 condensate of ethyleneoxide and propyleneoxide having a molecular weight of approximately 1500 to 10000, and specifically a polyoxyalkylenepolyglycol and an ester of the dicarboxylic acid, and an alkyleneoxide adduct of an alkylphenol-formaldehyde polycondensate.

[0046]

As mentioned above, the present invention is a hydraulic oil composition comprising 15 blending a specific base oil, components (A) to (D) and further these components and the component (E), and is a hydraulic oil composition typically comprising a specific base oil, components (A) to (D) and further these components and the component (E).

[0047]

The hydraulic oil composition of the present invention has good energy saving 20 properties, thermal stability (sludge resistance), wear resistance, scuffing resistance, demulsibility properties and friction-reducing properties of sliding parts. Therefore, it is suitably used as a hydraulic oil used for hydraulic equipment such as an injection molding machine, a machine tool, a construction machine and iron manufacturing equipment, and provides a good performance as a hydraulic oil for other hydraulic equipment, for example, an

industrial robot and a hydraulic elevator.

Examples

[0048]

Next, the present invention will be explained in more detail by examples, but the present invention is in no way limited by these examples.

Incidentally, the various properties were determined by the following methods.

(1) Properties of Base Oil

- Sulfur Content: Determined in accordance with JIS K 2541

- Content of saturated component: Determined in accordance with ASTM D 2007

- Absolute Viscosity at 40 °C: Determined by calculating from the kinematic viscosity at 40 °C measured in accordance with JIS K 2283 and the density

- Viscosity Index: Determined in accordance with JIS K 2283

[0049]

(2) Performance of Hydraulic Oil Composition

(a) High-Pressure Vane Pump Test

The power consumption (kW) and mechanical efficiency under normal operation are determined by forming a hydraulic circuit by using "TOKIMEC SQP2-12" as a vane pump and performing the operation under the conditions of oil temperature of 60 °C, revolution of 1200 rpm and pressure of 17.5 MPa.

(b) Thermal Stability Test

In accordance with "Testing Method for Thermal Stability of Lubricating Oils" specified in JIS K 2540, the thermal stability test is carried out in an air constant-temperature bath at 150 °C for 7 days and then the sample oil after testing is filtered with a filter to determine the sludge amount in the sample oil.

(c) Seizure Resistance by FZG Gear Test

In accordance with ASTM D 5182-91, FZG gear test is carried out under the conditions of 90 °C, 1450 rpm and 15 minutes and the seizure resistance is represented by the stage of scuffing generation load.

5 **(d) Demulsibility Properties**

In accordance with JIS K 2520, the demulsibility test at 54 °C is carried out to measure the time taken for the emulsion layer to reach 3 mL "degree of demulsification" (min).

(e) Friction Coefficient

10 Using a Bowden-type reciprocating dynamic friction tester, the friction coefficient μ is determined under the following conditions.

Oil temperature: 25 °C

Load: 19.6 N

Sliding distance: 40 mm

15 Sliding velocity: 60 mm/min

Sliding frequency: 5 reciprocations

Sliding material:

Rubber material for the upper part (U-801, manufactured by NOK Inc.)

20 Chrome coated steel plate for the lower part (50×100×1mm, manufactured by Test piece Inc.)

[0050]

The type of each component used in the preparation of the hydraulic oil composition is as follows.

(1) Base Oil-1: Paraffinic hydrogenated mineral oil conforming to API Classification,

Group III, having a sulfur content of not more than 0.01% by mass, a content of saturated component of 99% by mass, a viscosity index of 121 and an absolute viscosity at 40 °C of 29.21 mPa · s.

(2) Base Oil-2: Hydrogenated paraffinic mineral oil, having a sulfur content of not more than 0.01% by mass, a content of saturated component of 98% by mass, a viscosity index of 118 and an absolute viscosity at 40 °C of 34.96 mPa · s.

(3) Viscosity Index Improver: Polymethacrylate having a weight average molecular weight of 37000

(4) Acid Amide Compound: Condensate of isostearic acid and tetraethylenepentamine

(5) Acid Phosphate Ester-1: Oley lacid phosphate

(6) Acid Phosphate Ester-2: di-(2-ethylhexyl) phosphate

(7) Acid Phosphite Ester-1: Oleyl hydrogen phosphite

(8) Alkanolamine: N-alkyl di-ethanolamine

(9) Fatty Acid Glyceride: Glyceride Oleate (60% by mass of monoglyceride, 20% by mass of diglyceride and 20% by mass of triglyceride)

(10) Olefin Sulfide: Butene sulfide

(11) Thiocarbamate: Methylene bis(dibutyldithiocarbamate)

(12) Acid phosphate ester amine salt: Mono(di)-methyl acid phosphate dodecylamine

20 salt

(13) Triester Phosphate: Tricresylphosphate

(14) Antioxidant: 2,6-di-tert-butyl-4-methylphenol

(15) Rust-preventive Agent: Polyhydric alcohol alkenylsuccinate ester

(16) Metal Deactivator: Benzotriazole-based deactivator

(17) Demulsifying Agent: polyoxyethylenepolyoxypropylene glycol

(18) Antifoaming Agent: Polymethacrylate-based antifoaming agent

[0051]

Examples 1 to 4 and Comparative Example 1

5 Each hydraulic oil composition having the composition shown in Table 1 was prepared and the performance of each composition was evaluated. The results are shown in Table 1.

Meanwhile, there was used a Zn-based commercially available oil (hydraulic oil) having a viscosity index of 108 in Comparative Example 1.

10 [0052]

[Table 1]

15

20

			Examples				Comparative Example 1
			1	2	3	4	1
Blending Composition (% by mass)	Base oil-1		Residue	Residue	Residue	-	Zn-based commercially available oil
	Base oil-2		-	-	-	Residue	
	Viscosity Index Improver		5.00	5.00	5.00	5.00	
	Acid amide compound		0.05	0.08	0.05	0.10	
	Acid phosphate (Phosphite) ester	Acid phosphate ester-1	0.05	0.05	-	-	
		Acid phosphate ester -2	-	-	-	0.20	
		Acid phosphite ester-1	-	-	0.05	-	
	Lubricity improver	Alkanolamine	0.05	-	-	-	
		Fatty acid glyceride	-	-	-	0.05	
		Olefin sulfide	0.05	0.05	0.05	-	
		Thiocarbamate	-	-	-	0.20	
	Lubricity enhancer	Amine salt of acid phosphate ester	0.02	0.02	0.02	-	
		Phosphate triester	0.40	0.40	0.40	-	
	Other additives	Antioxidant	0.45	0.45	0.45	0.45	
		Rust-preventive agent	0.05	0.05	0.05	0.05	
		Metal deactivator	0.01	0.01	0.01	0.02	
		Demulsifying Agent	0.01	0.01	0.01	0.10	
		Antifoaming agent	0.10	0.10	0.10	0.10	
Performance Evaluation	Absolute viscosity (mPa · s)	40 °C	35.4	35.6	35.8	36.9	39.1
		60 °C	17.5	17.5	17.5	18.1	17.5
	Viscosity Index	-	157	157	157	160	108
	High-pressure vane pump test	Power Consumption (kW)	18.6	18.7	18.8	18.8	19.5
		Mechanical efficiency (%)	92.6	92.5	92.5	92.2	91.4
	Thermal stability	Sludge amount (mg/100 mL)	37	31	20	15	210
	Seizure resistance by FZG gear test (Scuffing Stage)		12	12	12	12	12
	Demulsibility properties (min) (Degree of demulsification)		20	15	15	20	20
	Friction coefficient μ by Bowden test		0.121	0.136	0.138	0.117	0.253

[0053]

From Table 1, the following facts are understood.

The results of the high-pressure vane pump test obtained in any of Examples 1 to 4 were excellent in both power consumption and mechanical efficiency. The results of the FZG test obtained in any of Examples 1 to 4 satisfied 10th stage or higher of the ISO specifications. The results of the thermal stability obtained in any of Examples 1 to 4 showed that the precipitation amount of sludge was extremely small compared with that of the Zn-based commercially available oil in Comparative Example 1. The results of the water separation properties test obtained in any of Examples 1 to 4 confirmed that excellent demulsibility properties might be maintained. The results of the Bowden test obtained in any of Examples 1 to 4 showed that the friction coefficient was reduced for the rubber material.

Industrial Applicability

[0054]

The hydraulic oil composition of the present invention has good energy saving properties, thermal stability (sludge resistance), wear resistance, seizure resistance (scuffing resistance), demulsibility properties, friction-reducing properties of sliding parts and the like, and is suitably used in the hydraulic machine field, machine tool field, industrial machine field and the like.

Claims

1. A hydraulic oil composition comprising blending

a base oil having a sulfur content of less than 0.03% by mass, a content of saturated component of not less than 90% by mass, a viscosity index of not less than 80 and an absolute
5 viscosity at 40 °C of 1 to 1000 mPa · s with

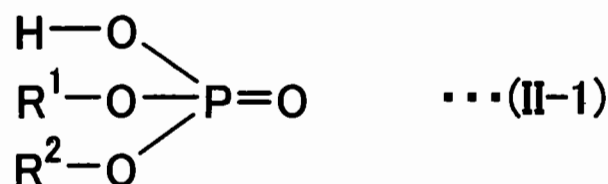
(A) 1 to 20% by mass of a polymethacrylate-based viscosity index improver having an weight average molecular weight of 10000 to 50000,

(B) 0.005 to 5% by mass of an acid amide compound,

(C) 0.005 to 5% by mass of an acid phosphate ester compound (c-1) represented by the

10 following general formula (II-1)

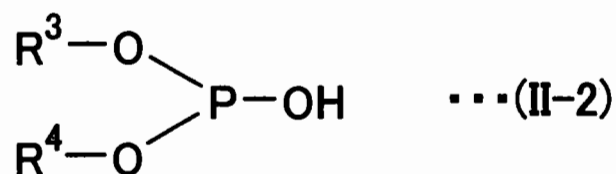
[Chemical Formula 1]



(In the formula, R¹ represents a hydrogen atom or a hydrocarbon group having 1 to 18 carbon atoms and R² represents a hydrocarbon group having 1 to 18 carbon atoms.) and/or an acid

15 phosphite ester compound (c-2) represented by the following general formula (II-2)

[Chemical Formula 2]



(In the formula, R³ represents a hydrogen atom or a hydrocarbon group having 1 to 18 carbon atoms and R⁴ represents a hydrocarbon group having 1 to 18 carbon atoms.), and

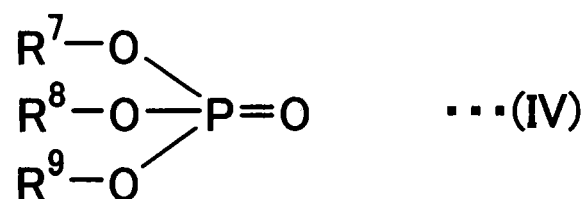
20 (D) 0.005 to 5% by mass of at least one kind selected from a polyhydric alcohol ester, an

alkanolamine, an olefin sulfide and a thiocarbamate compound.

2. Further, the hydraulic oil composition according to claim 1, comprising blending 0.005 to 5% by mass of at least one kind selected from (E) an amine salt of an acid phosphate ester compound and a phosphate triester compound represented by the following general formula

5 (IV):

[Chemical Formula 3]



(In the formula, R⁷ to R⁹ each independently represent a hydrocarbon group having 1 to 18 carbon atoms).

10