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(54) **METHOD OF FRICTION CONTROL**

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(57) **ABSTRACT**

This invention relates to a method of lubricating an internal combustion engine comprising at least one of a crankcase, a gear and a wet-clutch, said method comprising supplying to said crankcase, gear, and wet-clutch a lubricating composition containing: (a) an oil of lubricating viscosity; (b) a boron containing compound; and (c) a friction modifier.

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METHOD OF FRICTION CONTROL

FIELD OF INVENTION

[0001] The present invention relates to a method of friction control by lubricating an internal combustion engine comprising a crankcase and at least one of a gear and a wet-clutch with a lubricating composition.

BACKGROUND OF THE INVENTION

[0002] It is known that attempts have been made to produce a lubricant universally compatible with two-stroke and/or four-stroke internal combustion engines. The lubricants generally contain a number of different performance additives that are not necessarily designed for application in e.g. a four-stroke motorcycle engine where crankcase oil viscosity is required whilst also requiring properties compatible with extreme pressures and temperatures associated with a gearbox, transmission or clutch. Consequently many additives have properties that adversely effect engine performance or fuel economy.

[0003] Kasai et al. (2003 JSAE/SAE International Spring Fuels & Lubricants Meeting, Yokohama, Japan, May 19-22, 2003, Paper title Effect of Engine Oil Additives on Motorcycle Clutch System (SAE2003-01-1956 or JSAE 20030105) discloses borated dispersant in combination with detergents or zinc dithiophosphate as being suitable for friction control. Kasai et al. further states that engine oils containing friction modifiers cannot be applied in a 4-stroke motorcycle engine because they decrease clutch capacity.

[0004] U.S. Pat. No. 6,525,004 discloses a composition containing a borated hydrocarbyl succinimide dispersant and a phosphorus compound for use in 2-cycle and small engine four-cycle engines.

[0005] It would be advantageous to have a method of lubricating an internal combustion engine with at least one of a crankcase, a gear, a transmission system and a wet-clutch whilst imparting friction control. The present invention provides a method of lubricating an internal combustion engine whilst imparting friction control.

SUMMARY OF THE INVENTION

[0006] This invention provides a method of lubricating an internal combustion engine comprising a crankcase and at least one of a gear and a wet-clutch, said method comprising supplying to said crankcase and at least one of the gear and wet-clutch a lubricating composition comprising: (a) an oil of lubricating viscosity; (b) a boron containing compound; and (c) a friction modifier.

DETAILED DESCRIPTION OF THE INVENTION

[0007] This invention provides a method of lubricating an internal combustion engine comprising a crankcase and at least one of a gear and a wet-clutch, said method comprising supplying to said crankcase and at least one of the gear and wet-clutch a lubricating composition comprising: (a) an oil of lubricating viscosity; (b) a boron containing compound; and (c) a friction modifier.

Internal Combustion Engine

[0008] The internal combustion engine of the invention comprises a crankcase, a gear and a wet-clutch. Optionally the internal combustion engine further comprises a manual or automatic transmission. In one embodiment the gear is from a gearbox.

[0009] As used herein the term "wet-clutch" is known to a person skilled in the art as meaning one that contains a clutch plate(s) that is bathed or sprayed by a lubricant, e.g., that of the transmission, and the lubricating oil gets between the plate(s).

[0010] In one embodiment the internal combustion engine has a common oil reservoir supplying the same lubricating composition to the crankcase and at least one of a gear and a wet-clutch. In certain embodiments the lubricating composition is supplied to the crankcase and to the gear (or multiplicity of gears), or to the crankcase and the wet clutch, or to the crankcase and both the gear (or gears) and the wet clutch.

[0011] In one embodiment the internal combustion engine is a 4-stroke engine. In one embodiment the internal combustion engine is also referred to generically as a small engine.

[0012] The small engine in one embodiment has a power output of 2.24 to 18.64 kW (3 to 25 horsepower (hp)), in another embodiment 2.98 to 4.53 kW (4 to 6 hp) and in another embodiment exhibits 100 or 200 cm³ displacement. Examples of small engines include those in home/garden tools such as lawnmowers, hedge trimmers, chainsaws, snow blowers or roto-tillers.

[0013] In one embodiment the internal combustion engine has a capacity of up to 3500 cm³ displacement, in another embodiment up to 2500 cm³ displacement and in another embodiment up to 2000 cm³ displacement. Examples of suitable internal combustion engines with a capacity up to 2500 cm³ displacement include motorcycles, snowmobiles, jet-skis, quad-bikes, or all-terrain vehicles. In one embodiment the internal combustion engine is a tractor or other agricultural vehicle such as a combined harvester.

[0014] In one embodiment the internal combustion engine is not a tractor or other agricultural vehicle. In another embodiment the internal combustion engine does not contain a dry-clutch i.e. a system that separates the engine from the transmission such as a transmission on an automotive vehicle. In another embodiment the internal combustion engine is not suitable for use with a diesel fuel.

[0015] In one embodiment the internal combustion engine is a 4-stroke engine. In one embodiment the internal combustion engine is suitable for motorcycles for example motorcycles with a 4-stroke internal combustion engine.

Oil of Lubricating Viscosity

[0016] The lubricating composition includes natural or synthetic oils of lubricating viscosity; oil derived from hydrocracking, hydrogenation or hydrofinishing; and unrefined, refined and re-refined oils, and mixtures thereof.

[0017] Natural oils include animal oils, vegetable oils, mineral oils and mixtures thereof. Synthetic oils include hydrocarbon oils, silicon-based oils, and liquid esters of phosphorus-containing acids. Synthetic oils may be pro-

duced by Fischer-Tropsch gas-to-liquid synthetic procedure as well as other gas-to-liquid oils. In one embodiment the polymer composition of the present invention is useful when employed in a gas-to-liquid oil. Often Fischer-Tropsch hydrocarbons or waxes may be hydroisomerised.

[0018] In one embodiment the base oil is a polyalphaolefin (PAO) including a PAO-2, PAO-4, PAO-5, PAO-6, PAO-7 or PAO-8 (the numerical value relating to Kinematic Viscosity at 100° C.). The polyalphaolefin in one embodiment is prepared from dodecene and in another embodiment from decene.

[0019] Oils of lubricating viscosity may also be defined as specified in the American Petroleum Institute (API) Base Oil Interchangeability Guidelines. In one embodiment the oil of lubricating viscosity comprises an API Group I, II, III, IV, V, VI oil or mixtures thereof, and in another embodiment API Group II, III, IV oil or mixtures thereof. In another embodiment the oil of lubricating viscosity is a Group III or IV base oil and in another embodiment a Group IV base oil. If the oil of lubricating viscosity is an API Group II, III, IV, V or VI oil there may be up to about 40 wt % and in another embodiment up to a maximum of about 5 wt % of the lubricating oil an API Group I oil present.

[0020] In one embodiment the lubricating composition has a SAE viscosity grade from XW-Y, wherein X is an integer from 0 to 20 and Y is an integer from 20 to 50.

[0021] In one embodiment X is an integer chosen from 0, 5, 10, 15 or 20.

[0022] In one embodiment Y is an integer chosen from 20, 25, 30, 35, 40, 45 or 50.

[0023] The oil of lubricating viscosity in one embodiment is present from 40 wt % to 99.98 wt % of the lubricating composition, in another embodiment from 60 wt % to 99.87 wt % of the lubricating composition and in another embodiment from 69 wt % to 98.85 wt % of the lubricating composition.

Boron Containing Compound

[0024] The boron containing compound of the invention includes a borate ester, a borate alcohol, a borated dispersant or mixtures thereof.

[0025] The boron containing compound in one embodiment is present from 0.01 wt % to 20 wt %, in another embodiment 0.1 wt % to 10 wt %, and in another embodiment 1 wt % to 8 wt % weight percent of the lubricating composition.

Borate Ester or Borate Alcohol

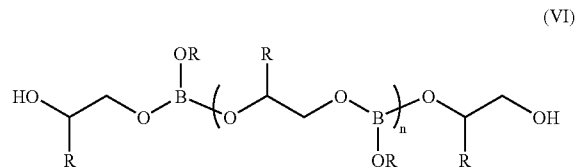
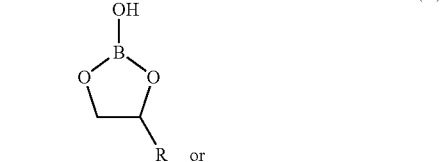
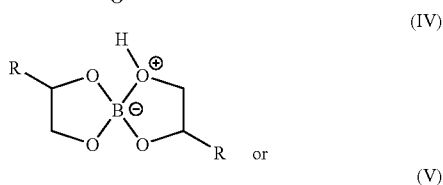
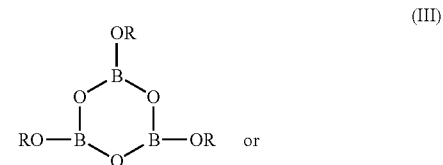
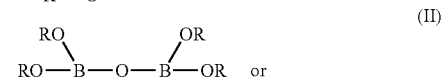
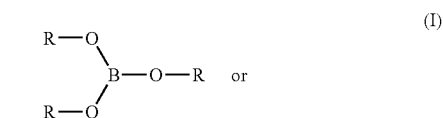
[0026] In one embodiment the boron containing compound is a borate ester or a borate alcohol. The borate ester or borate alcohol compounds are substantially the same except the borate alcohol has at least one hydroxyl group that is not esterified. Therefore, as used herein the term "borate ester" is used to refer to either borate ester or borate alcohol.

[0027] The borate ester may be prepared by the reaction of a boron compound and at least one compound selected from epoxy compounds, halohydrin compounds, epihalohydrin compounds, alcohols and mixtures thereof. The alcohols include monohydric alcohols, dihydric alcohols, trihydric

alcohols or higher alcohols, with the proviso for one embodiment that hydroxyl groups are on adjacent carbon atoms i.e. vicinal. Hereinafter "epoxy compounds" is used when referring to "at least one compound selected from epoxy compounds, halohydrin compounds, epihalohydrin compounds and mixtures thereof."

[0028] Boron compounds suitable for preparing the borate ester include the various forms selected from the group consisting of boric acid (including metaboric acid, HBO_2 , orthoboric acid, H_3BO_3 , and tetraboric acid, $\text{H}_2\text{B}_4\text{O}_7$), boric oxide, boron trioxide and alkyl borates. The borate ester may also be prepared from boron halides.

[0029] In one embodiment the borate ester is formed by the reaction of a boron compound with an epoxy compound, dihydric alcohols, trihydric alcohols or higher alcohols. The borate ester may be represented by at least one of formulae (I) to (VI):



wherein each R may be hydrogen or hydrocarbyl groups provided that the borate ester is oil soluble.

[0030] In one embodiment at least two of the R groups per the above formulae are hydrocarbyl groups. The hydrocarbyl groups may be alky or aryl groups or cyclic groups in which two adjacent R groups are connected in a ring. When R is alkyl, the group may be saturated or unsaturated. In one embodiment the hydrocarbyl group is an unsaturated alkyl.

In one embodiment the hydrocarbyl group is cyclic. In one embodiment the hydrocarbyl groups are mixtures of alkyl and cycloalkyl.

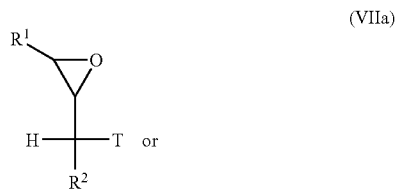
[0031] Generally there is no upper limit on the number of carbon atoms in the molecule, but a practical limit in one embodiment is 500, in another embodiment 400, in another embodiment 200, in another embodiment 100 and in another embodiment 60. For example the number of carbon atoms present in each R may be 1 to 60, 1 to 40 or 1 to 30 carbon atoms, provided the total number of carbon atoms on the R groups in one embodiment is 9 or more, in another embodiment 10 or more, in another embodiment 12 or more and in another embodiment 14 or more.

[0032] In one embodiment all R groups are hydrocarbyl groups containing 1 to 30 carbon atoms, provided the total number of carbon atoms is 9 or more.

[0033] In one embodiment the boron containing compound is represented by formula (I) described above. In this embodiment, the borate ester represented by formula (1) contains three hydrocarbyl R groups each containing in one embodiment 1 to 8 carbon atoms, in another embodiment 2 to 7 carbon atoms and in another embodiment 3 to 6 carbon atoms, provided the total number of carbon atoms on the R groups is 4 or more, 6 or more, or 8 or more.

[0034] Examples of R groups include isopropyl, n-butyl, isobutyl, amyl, 2-pentenyl, 4-methyl-2-pentyl, 2-ethyl-1-hexyl, 2-ethylhexyl, heptyl, isooctyl, nonyl, decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, nonadecyl and eicosyl groups.

[0035] The epoxy compounds useful for preparing the borate ester of the invention includes materials that may be represented by the formulae (VIIa) or (VIIb):



wherein

[0036] R^1 in one embodiment is an alkyl chain containing 1 to 4 or 1 to 2 carbon atoms, and in another embodiment hydrogen;

[0037] R^2 is an alkyl chain containing 8 to 30 or 10 to 26 or 12 to 22 carbon atoms; and

[0038] T is independently hydrogen or a halogen.

[0039] In one embodiment T is a halogen, such as, chlorine, bromine, iodine or fluorine or mixtures thereof and the epoxy compounds are epihalohydrin compounds. In one embodiment T is chlorine. In one embodiment T is hydrogen.

[0040] In one embodiment the epoxy compounds of the invention include commercial mixtures of C_{14} - C_{16} epoxides or C_{14} - C_{18} epoxides. In one embodiment, the epoxy compounds of the invention have been purified. Examples of suitable purified epoxy compounds may include 1,2-epoxydecane, 1,2-epoxyundecane, 1,2-epoxydodecane, 1,2-epoxytridecane, 1,2-epoxybutadecane, 1,2-epoxypentadecane, 1,2-epoxyhexadecane, 1,2-epoxyheptadecane, 1,2-epoxyoctadecane, 1,2-epoxynonadecane and 1,2-epoxyicosane. In one embodiment purified epoxy compounds include 1,2-epoxytetradecane, 1,2-epoxypentadecane, 1,2-epoxyhexadecane, 1,2-epoxyheptadecane, 1,2-epoxyoctadecane. In one embodiment purified epoxy compounds include 1,2-epoxyhexadecane.

[0041] In one embodiment the dihydric alcohols, trihydric alcohols or higher alcohols contain 2 to 30, 4 to 26 or 6 to 20 carbon atoms. The alcohol compounds may include glycerol compounds, such as, glycerol monooleate.

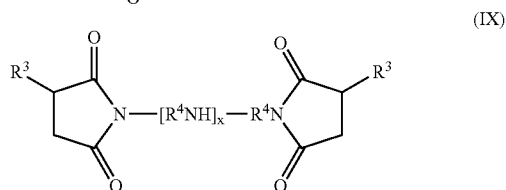
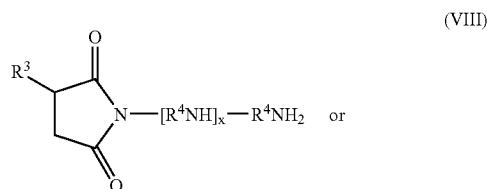
[0042] The borate ester may be prepared by blending the boron compound and the epoxy compounds or alcohols described above and heating them at a suitable temperature, such as 80° C. to 250° C., 90° C. to 240° C. or 100° C. to 230° C., until the desired reaction has occurred. The molar ratio of the boron compounds to the epoxy compounds is typically 4:1 to 1:4, 1:1 to 1:3, or about 1:2. An inert liquid may be used in performing the reaction. The liquid may be, for instance, toluene, xylene, chlorobenzene, dimethylformamide and mixtures thereof. Water is typically formed and is distilled off during the reaction. Alkaline reagents may be used to catalyze the reaction.

[0043] In one embodiment suitable borate ester compounds include tripropyl borate, tributyl borate, tripentyl borate, trihexyl borate, triheptyl borate, trioctyl borate, trinonyl borate and tridecyl borate.

[0044] In one embodiment the borate ester compounds include tributyl borate, tri-2-ethylhexyl borate or mixtures thereof.

Borated Dispersant

[0045] In another embodiment, the boron containing compound is a borated dispersant typically derived from an N-substituted long chain alkenyl succinimide. The N-substituted long chain alkenyl succinimide has a variety of chemical structures and two typical formulae include:



wherein

[0046] each R^3 is independently an alkyl group;

[0047] each R^4 is an alkylene group; and

[0048] each repeat unit x is an integer from 1 to 20, 1 to 15 or 1 to 10.

[0049] In one embodiment R is a polyisobutyl group with a number average molecular weight of 350 to 5000, or 500 to 3000 or 550 to 1500, such as 550, 750 or 950 to 1000, or alternatively 1500 to 2500. In one embodiment R^3 is further substituted by additional succinimide functionality.

[0050] In one embodiment R^4 is an ethylene (C_2H_4) group.

[0051] The N-substituted long chain alkenyl succinimides are borated using a variety of agents including boric acid (for example, metaboric acid, HBO_2 , orthoboric acid, H_3BO_3 , and tetraboric acid, $H_2B_4O_7$), boric oxide, boron trioxide, and alkyl borates described in formulae (I) to (VI) above. In one embodiment the borating agent is boric acid which may be used alone or in combination with other borating agents.

[0052] The borated dispersant may be prepared by blending the boron compound and the N-substituted long chain alkenyl succinimides and heating them at a suitable temperature, such as, $80^\circ C.$ to $250^\circ C.$, $90^\circ C.$ to $230^\circ C.$ or $100^\circ C.$ to $210^\circ C.$, until the desired reaction has occurred. The molar ratio of the boron compounds to the N-substituted long chain alkenyl succinimides in one embodiment is 10:1 to 1:4, in another embodiment 4:1 to 1:3, and in another embodiment 1:2. An inert liquid may be used in performing the reaction. The liquid may include toluene, xylene, chlorobenzene, dimethylformamide or mixtures thereof.

Friction Modifiers

[0053] The friction modifiers of the invention include a molybdenum dithiocarbamate, a molybdenum thiophosphate, a long chain fatty acid ester or mixtures thereof.

[0054] In one embodiment the friction modifier is present at 0.01 wt % to 10 wt %, in another embodiment 0.02 wt % to 5 wt % and in another embodiment 0.05 wt % to 3 wt % of the lubricating composition.

Long Chain Fatty Acid Ester

[0055] In one embodiment the friction modifier is a long chain fatty acid ester. In another embodiment the long chain fatty acid ester is a mono-ester and in another embodiment the long chain fatty acid ester is a (tri)glyceride.

[0056] The long chain fatty acid ester or glyceride in one embodiment is derived from fatty acids, which are a class of compounds containing a long hydrocarbon chain and a terminal carboxylate group and are characterised as unsaturated or saturated. In one embodiment the long chain fatty acid ester is derived from the reaction of a long chain fatty acid with an alcohol.

[0057] The long chain fatty acid compounds may be saturated or unsaturated, aliphatic, acyclic or aryl. When aliphatic, the long chain fatty acid compounds may have a hydrocarbyl group that is linear or branched. In one embodiment the hydrocarbyl group is a linear group. In one embodiment the long chain fatty acid compounds contain 12 to 24 carbon atoms, for example mixtures of carboxylic acids containing 14 to 20 or 16 to 18 carbon atoms. In one

embodiment the aliphatic carboxylic acid contains a straight chain hydrocarbyl group. Such acids may be used in combination with acids with more or fewer carbon atoms as well.

[0058] Examples of unsaturated long chain fatty acid compounds include carboxylic acids, such as, myristoleic acid, palmitoleic acid, oleic acid or linolenic acid. Examples of saturated fatty acids include lauric acid, myristic acid, palmitic acid, stearic acid, arachidic acid, behenic acid lignoceric acid or mixtures thereof.

[0059] Typically the alcohol is a polyol including diols, triols, and alcohols with higher numbers of alcoholic OH groups (often referred to as polyhydric alcohols). Polyhydric alcohols include ethylene glycols, including di-, tri- and tetraethylene glycols; propylene glycols, including di-, tri- and tetrapropylene glycols; glycerol; butane diol; hexane diol; sorbitol; arabitol; mannitol; sucrose; fructose; glucose; cyclohexane diol; erythritol; and pentaerythritols, including di- and tripentaerythritol. In one embodiment the polyol includes diethylene glycol, triethylene glycol, glycerol, sorbitol, pentaerythritol or dipentaerythritol.

[0060] In one embodiment the friction modifier is a monoester of a polyol and an aliphatic carboxylic acid. In one embodiment the monoester is glycerol monooleate. It is to be understood that glycerol monooleate, as is the case with other such materials, in its commercially available grade, is a mixture which includes such materials as glycerol, oleic acid, other long chain acids, glycerol dioleate, and glycerol trioleate. The commercial material is believed to include about 60 ± 5 percent by weight of the chemical species "glycerol monooleate," along with 35 ± 5 percent glycerol dioleate, and less than about 5 percent trioleate and oleic acid. The amounts of the monoesters, described below, are the amounts of the commercial grade material.

[0061] In one embodiment the monoester of a polyol and an aliphatic carboxylic acid is in the form of a mixture with a sunflower oil or the like, which in one embodiment is present in the friction modifier mixture from 5 to 95 wt %, in another embodiment from 10 to 90 wt %, in another embodiment from 20 to 85 wt % and in another embodiment from 20 to 80 wt % of said mixture.

[0062] In one embodiment the long chain fatty acid ester is beef tallow oil, lard oil, palm oil, castor oil, cottonseed oil, corn oil, peanut oil, soybean oil, sunflower oil, olive oil, whale oil, menhaden oil, sardine oil, coconut oil, palm kernel oil, babassu oil, rape oil, soya oil or linseed oil.

Molybdenum Dithiocarbamate

[0063] In one embodiment the friction modifier is a molybdenum dithiocarbamate (MoDTC). Specific examples of MoDTC's include commercial materials such as Van-lube™ 822 and Molyvan™ A from R.T. Vanderbilt Co., Ltd., and Adeka Sakura-Lube™ S-100, S-165 and S-600 from Asahi Denka Kogyo K. K. Other molybdenum dithiocarbamates are described by Ward in U.S. Pat. No. 4,846,983; by de Vries et al. in U.S. Pat. No. 4,265,773 and by Inoue et al. in U.S. Pat. No. 4,529,536.

Additional Performance Additives

[0064] In one embodiment the method optionally includes at least one additional performance additive. The additional performance additive includes at least one of metal deactivators, detergents, dispersants, viscosity modifiers, dispers-

ant viscosity modifiers, extreme pressure agents, antiwear agents, antioxidants, corrosion inhibitors, foam inhibitors, demulsifiers, pour point depressants, seal swelling agents and mixtures thereof. In one embodiment the additional performance additives may be used alone or in combination.

[0065] In one embodiment the total combined amount of the other performance additive compounds present ranges from 0 wt % to 30 wt %, in another embodiment from 0.01 wt % to 25 wt % and in another embodiment 0.1 wt % to 20 wt % of the lubricating composition. Although one or more of the other performance additives may be present, it is common for the other additional performance additives to be present in different amounts relative to each other.

[0066] If the present invention is in the form of a concentrate (which may be combined with additional oil to form, in whole or in part, a finished lubricant), the ratio of the various additives to the oil of lubricating viscosity and/or to diluent oil include the ranges of 80:20 to 10:90 by weight.

[0067] Antioxidants include sulphurised olefins, hindered phenols, diphenylamines; detergents include neutral or over-based, Newtonian or non-Newtonian, basic salts of alkali, alkaline earth and transition metals with one or more of a phenate, a sulphurised phenate, a sulphonate, a carboxylic acid, a phosphorus acid, a mono- and/or a di-thiophosphoric acid, a saligenin, an alkylsalicylate, a salixarate; and dispersants include N-substituted long chain alkenyl succinimide as well as post treated version thereof (excluding post treating with boron compounds). Post-treated dispersants include those further treated by reaction with materials such as urea, thiourea, dimercaptotriadiazoles, carbon disulphide, aldehydes, ketones, carboxylic acids, hydrocarbon-substituted succinic anhydrides, nitriles, epoxides and phosphorus compounds.

[0068] Antiwear agents include compounds such as metal thiophosphates, especially zinc dialkyldithiophosphates; phosphoric acid esters or salt thereof; phosphites; and phosphorus-containing carboxylic esters, ethers, and amides; anticuffing agents including organic sulphides and polysulphides, such as benzyldisulphide, bis-(chlorobenzyl)disulphide, dibutyl tetrasulphide, di-tertiary butyl polysulphide, di-tert-butylsulphide, sulphurised Diels-Alder adducts or alkyl sulphenyl N'N-dialkyl dithiocarbamates. Extreme pressure (EP) agents including chlorinated wax, organic sulphides and polysulphides, such as benzyldisulphide, bis-(chlorobenzyl)disulphide, dibutyl tetrasulphide, sulphurised methyl ester of oleic acid, sulphurised alkylphenol, sulphurised dipentene, sulphurised terpene, and sulphurised Diels-Alder adducts; phosphosulphurised hydrocarbons, metal thiocarbamates, such as zinc dioctyldithiocarbamate and barium heptylphenol diacid; may also be used in the composition of the invention.

[0069] The viscosity modifiers include hydrogenated copolymers of styrene-butadiene, ethylene-propylene polymers, polyisobutenes, hydrogenated styrene-isoprene polymers, hydrogenated isoprene polymers, polymethacrylate acid esters, polyacrylate acid esters, polyalkyl styrenes, alkenyl aryl conjugated diene copolymers, polyolefins, polyalkylmethacrylates and esters of maleic anhydride-styrene copolymers. Dispersant viscosity modifiers (often referred to as DVMs) include functionalised polyolefins, for example, ethylene-propylene copolymers that have been functionalized with the reaction product of maleic anhydride

and an amine, polymethacrylates functionalised with an amine (e.g., from incorporation of a nitrogen-containing comonomer), or styrene-maleic anhydride copolymers reacted with an amine.

[0070] Additional performance additives such as corrosion inhibitors include octylamine octanoate, condensation products of dodecenyl succinic acid or anhydride and a fatty acid such as oleic acid with a polyamine; metal deactivators including derivatives of benzotriazoles, 1,2,4-triazoles, benzimidazoles, 2-alkyldithiobenzimidazoles or 2-alkyldithiobenzothiazoles; foam inhibitors including copolymers of ethyl acrylate and 2-ethylhexylacrylate and optionally vinyl acetate; demulsifiers including polyethylene glycols, polyethylene oxides, polypropylene oxides and (ethylene oxide-propylene oxide) polymers; pour point depressants including esters of maleic anhydride-styrene, polymethacrylates, polyacrylates or polyacrylamides; and seal swell agents including Exxon Necton-37™ (FN 1380) and Exxon Mineral Seal Oil (FN 3200); may also be used in the composition of the invention.

[0071] The following examples provide an illustration of the invention. These examples are non exhaustive and are not intended to limit the scope of the invention.

EXAMPLES

Examples 1-2 and Reference Examples 1-2

[0072] A composition is prepared by blending additives as shown in Table 1 into a 10W-40 lubricant. The amounts in Table 1 are presented inclusive of diluent oil and for glycerol monooleate the other components in the commercial grade material.

TABLE 1

Additive	Reference Example 1	Example 1	Reference Example 2	Example 2
Borated Succinimide (wt %)	0	5	0	5
Glycerol Monooleate (wt %)	0.2	0.2	0.8	0.8

Friction Test

[0073] A friction test is carried out employing a commercially available Variable Speed Friction Test instrument. The instrument employed in the test is modified by replacing the standard lower plate with a 1998 Yamaha YZF1000 R1 motorcycle clutch plate sections. The instrument upper plate is also modified with a small diameter track to fit a shallow C shape (a 30° segment) clutch plate section of the following dimensions: 13 mm wide, the long 'side' of the C is 38 mm, the short side is 32 mm. The instrument is operated at 100° C., with a linear slip velocity of 0.2 m/s and a load of 59 N (or 6 kgf). Before measuring friction of co-efficient, the instrument is allowed to equilibrate under the conditions mentioned above. The instrument is then run on the samples for 60 minutes. The results obtained for Examples 1-2 and Reference Examples 1-2 are shown in Table 2.

TABLE 2

	Reference Example 1	Example 1	Reference Example 2	Example 2
Co-Efficient of Friction	0.27	0.37	0.25	0.31

[0074] Overall the results show that the presence of a boron containing compound allows friction modifiers to be present in a lubricating composition for an internal combustion engine with at least one of a crankcase, a gear and a wet-clutch without excessive reduction in the coefficient of friction.

[0075] In this specification the terms “hydrocarbyl substituent” or “hydrocarbyl group,” as used herein are used in its ordinary sense, which is well-known to those skilled in the art. Specifically, it refers to a group primarily composed of carbon and hydrogen atoms and attached to the remainder of the molecule through a carbon atom and which does not exclude the presence of other atoms or groups in a proportion insufficient to detract from the molecule having a predominantly hydrocarbon character. In general, no more than two, in one aspect no more than one, non-hydrocarbon substituent will be present for every ten carbon atoms in the hydrocarbyl group; typically, there will be no non-hydrocarbon substituents in the hydrocarbyl group. A more detailed definition of the terms “hydrocarbyl substituent” or “hydrocarbyl group,” is provided in U.S. Pat. No. 6,583,092.

[0076] Each of the documents referred to above is incorporated herein by reference. Except in the Examples, or where otherwise explicitly indicated, all numerical quantities in this description specifying amounts of materials, reaction conditions, molecular weights, number of carbon atoms, and the like, are to be understood as modified by the word “about.” Unless otherwise indicated, each chemical or composition referred to herein should be interpreted as being a commercial grade material. However, the amount of each chemical component is presented exclusive of any solvent or diluent oil, which may be customarily present in the commercial material, unless otherwise indicated. It is to be understood that the upper and lower amount, range, and ratio limits set forth herein may be independently combined. Similarly, the ranges and amounts for each element of the invention may be used together with ranges or amounts for any of the other elements.

What is claimed is:

1. A method of lubricating an internal combustion engine comprising a crankcase and at least one of a gear and a

wet-clutch, said method comprising supplying to said crankcase and at least one of the gear and wet-clutch a lubricating composition comprising:

- (a) an oil of lubricating viscosity;
- (b) a boron containing compound; and
- (c) a friction modifier.

2. The method of claim 1, wherein the lubricating composition is supplied to the crankcase and to the gear (or multiplicity of gears).

3. The method of claim 1, wherein the lubricating composition is supplied to the crankcase and the wet clutch.

4. The method of claim 1, wherein the lubricating composition is supplied to the crankcase and both the gear (or gears) and the wet clutch.

5. The method of claim 1, wherein the boron containing compound comprises a borate ester, a borate alcohol, a borated dispersant or mixtures thereof.

6. The method of claim 1, wherein the boron containing compound is a borated dispersant.

7. The method of claim 1, wherein the boron containing compound is an N-substituted long chain alkenyl succinimide.

8. The method of claim 1, wherein the N-substituted long chain alkenyl succinimide comprises a polyisobutyl group with a number average molecular weight of 350 to 5000, or 550 to 1500.

9. The method of claim 1, wherein the boron containing compound is present from 0.01 wt % to 20 wt %, or 1 wt % to 8 wt % weight percent of the lubricating composition.

10. The method of claim 1, wherein the friction modifiers comprise a molybdenum dithiocarbamate, a molybdenum thiophosphate, a long chain fatty acid ester or mixtures thereof.

11. The method of claim 10, wherein the long chain fatty acid ester is a mono-ester or a (tri)glyceride.

12. The method of claim 1, wherein the friction modifier is present at 0.01 wt % to 10 wt %, or 0.05 wt % to 3 wt % of the lubricating composition.

13. The method of claim 1, wherein the lubricating composition has a SAE viscosity grade from XW-Y, wherein X is an integer from 0 to 20 and Y is an integer from 20 to 50.

14. The method of claim 1, wherein the internal combustion engine is a 4-stroke engine.

15. The method of claim 1, wherein the 4-stroke engine is a motorcycle engine.

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