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(54) Boron containing lubricating oil compositions

(57) A crankcase lubricating oil composition comprises an oil of lubricating viscosity, in a major amount, and, in respective minor amounts, a boron-containing additive and one or more co-additives, wherein the lubricating oil composition has greater than 200 ppm by mass of boron, less than 600 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition.

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Description

[0001] This invention relates to lubricating oil compositions, more especially to compositions suitable for use in piston engine, especially gasoline (spark-ignited) and diesel (compression-ignited), crankcase lubrication. Such compositions may be referred to as crankcase lubricants.

[0002] Most of the moving parts of an internal combustion engine are in a state of hydrodynamic lubrication, but, some sliding parts, such as pistons and valve trains, are in a mixed or boundary lubrication state. To provide wear resistance caused by friction in these lubrication states, it has been necessary to provide the engine oil with additives to reduce wear. For many years, zinc dialkyldithiophosphates ("ZDDP's") have been used as standard antiwear additives.

[0003] A problem arising from the use of ZDDP's is their phosphorus content: phosphorus derivatives deriving from the ZDDP's can poison the components of exhaust gas catalytic converters. Calatytic converters are used to reduce pollution and to meet governmental regulations requiring reduction in the levels of undesirable gases, such as hydrocarbons, carbon monoxide, and oxides of nitrogen, from internal engine combustion exhaust emissions. Such converters use catalysts which are installed in the exhaust streams, e.g. the exhausts of automobiles, to treat the undesirable gases. Phosphorus derivatives, such as decomposition products of ZDDP's, can be carried into the exhaust, where they are believed to poison the catalyst. Accordingly, the use of engine oils containing phosphorus additives may substantially reduce the life and effectiveness of catalytic converters. Therefore, it would be desirable to reduce, or eliminate, the phosphorus-content of engine oils so as to maintain the activity and extend the life of catalytic converters. Also, it is possible that sulfur-containing components may poison the catalysts, for example those used to reduce the levels of oxides of nitrogen.

[0004] Governmental and automotive industry pressure to reduce the phosphorus and sulfur content of lubricating oil compositions therefore exists. However, if this were done, for example by reducing the level of ZDDP, the anti-wear performance of the lubricating oil composition would be lessened. The art has addressed this problem in a number of ways, for example:

WO 96/37582 describes a lubricating oil composition comprising a sulfoxymolybdenum dithiocarbamate, a zinc dialkyldithiophosphate, and a defined proportion of calcium and magnesium salicylate, wherein the amount of molybdenum derived from the molybdenum compound is 200 to 1000 ppm, the amount of phosphorus derived from the zinc compound is 0.04 to 0.15 mass %, and the amount of the metal salicylates is 0.5 to 10 mass %.

EP-A-0 280 579 and EP-A-0 280 580 describe lubricating oil compositions with reduced or zero amounts of zinc and phosphorus, which comprise 5 to 500 ppm of copper in oil-soluble form, one or more sulfur-containing compounds providing 0.5 to 2.0 mass % of sulfur and a bearing corrosion inhibitor.

EP-A-0 609 623, US-A-5,629,272 and EP-A-0 814 148 describe oil compositions comprising a metal-containing detergent, a ZDDP and a boron-containing ashless dispersant, characterised in that the compositions further comprise an antiwear agent having an aliphatic amide and either a dithiocarbamate compound or an ester of a fatty acid and boric acid.

[0005] It has now been surprisingly found, according to this invention, that certain levels of boron can endow crankcase lubricating oil compositions with satisfactory anti-wear performance, even oil compositions with low levels of both phosphorus and sulfur.

[0006] Accordingly, in a first aspect, the invention provides a crankcase lubricating oil composition comprising, or made by admixing, an oil of lubricating viscosity in a major amount, and, in respective minor amounts, a boron-containing additive and one or more co-additives, wherein the lubricating oil composition has greater than 200 ppm by mass of boron, less than 600 ppm by mass of phosphorus and less than 6000, preferably less than 5000, such as less than 4000, ppm by mass of sulfur, based on the mass of the oil composition.

[0007] In a second aspect, the invention provides a crankcase lubricating oil composition comprising, or made by admixing, an oil of lubricating viscosity in a major amount, and, in respective minor amounts, a boron-containing additive and one or more co-additives, wherein the lubricating oil composition has greater than 300 ppm by mass of boron, less than 900 ppm by mass of phosphorus and less than 6000, preferably less than 5000, such as less than 4000, ppm by mass of sulfur, based on the mass of the oil composition.

[0008] In a third aspect, the invention provides a crankcase lubricating oil composition comprising, or made by admixing, an oil of lubricating viscosity in a major amount, and, in respective minor amounts, a boron-containing additive, a detergent additive composition and one or more co-additives, wherein the lubricating oil composition has greater than 50 ppm by mass of boron, less than 800 ppm by mass of phosphorus and less than 6000, preferably less than 5000, such as less than 4000, ppm by mass of sulfur, based on the mass of the oil composition, provided that the

detergent additive composition comprises at least two detergents of at least two metals.

[0009] In a fourth aspect, the invention provides an additive composition comprising, or made by admixing, a diluent or carrier oil, a boron-containing additive and one or more co-additives in such proportions so to provide a crankcase lubricating oil composition having greater than 200 ppm or boron, less than 600 ppm by mass of phosphorus and less than 6000, preferably less than 5000, such as less than 4000, by mass ppm by mass of sulfur, based on the mass of the oil composition, when the oil composition contains 4 to 10 mass % of the additives.

[0010] In a fifth aspect, the invention provides an additive composition comprising, or made by admixing, a diluent or carrier oil, a boron-containing additive and one or more co-additives in such proportions so to provide a crankcase lubricating oil composition having greater than 300 ppm or boron, less than 900 ppm by mass of phosphorus and less than 6000, preferably less than 5000, such as less than 4000, by mass ppm by mass of sulfur, based on the mass of the oil composition, when the oil composition contains 4 to 10 mass % of the additives.

[0011] In a sixth aspect, the invention provides an additive composition comprising, or made by admixing, a diluent or carrier oil, a boron-containing additive, a detergent additive composition comprising at least two detergents of at least two metals and one or more co-additives in such proportions so to provide a crankcase lubricating oil composition having greater than 50 ppm by mass of boron, less than 800 ppm by mass of phosphorus and less than 6000, preferably less than 5000, such as less than 4000, ppm by mass of sulfur, based on the mass of the oil composition, when the oil composition contains 4 to 10 mass % of the additives.

[0012] In a seventh aspect, the invention provides a method for conferring wear resistance to a crankcase lubricating oil composition that contains less than 900 ppm by mass of phosphorus and less than 6000, preferably less than 5000, such as less than 4000, ppm by mass of sulfur, based on the mass of the oil composition, by provision in the oil composition of a boron-containing additive to provide greater than 50 ppm by mass of boron based on the mass of the oil composition.

[0013] In an eighth aspect, the invention provides a method of lubricating the crankcase of a spark-ignited or a compression-ignited internal combustion engine which comprises supplying to the engine a lubricating oil composition according to the first, second or third aspect of the invention.

[0014] In a ninth aspect, the invention provides the use of an effective amount of a boron-containing additive in a crankcase lubricating oil composition that contains less than 900 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition, to provide wear resistance, in particular in the Peugeot TU3M Scuffing Test and Sequence IVA Test. An effective amount is preferably an amount sufficient to provide at least 50 ppm by mass of boron based on mass of the oil composition.

[0015] In this specification:

"Major amount" means in excess of 50 mass % of the composition.

"Minor amount" means less than 50 mass % of the composition, both in respect of the stated additive and in respect of the total mass % of all of the additives present in the composition, reckoned as active ingredient of the additive or additives.

"Comprises or comprising" or cognate words are taken to specify the presence of stated features, steps, integers, or components, but do not preclude the presence or addition of one or more other features, steps, integers, components or groups thereof.

"TBN" is Total Base Number as measured by ASTM D2896.

"Oil-soluble" or "oil-dispersible" does not necessarily indicate that the additives are soluble, dissolvable, miscible or capable of being suspended in the oil of lubricating viscosity, in all proportions. They do mean, however, that they are, for example, soluble or stably dispersible in the oil to an extent sufficient to exert their intended effect in the environment in which the oil is employed. Moreover, the additional incorporation of other additives may also permit incorporation of higher levels of a particular additive, if desired.

"ppm" means parts per million, expressed by mass based on the mass of the lubricating oil composition.

[0016] All percentages reported are mass % on an active ingredient basis, i.e., without regard to carrier or diluent oil, unless otherwise stated.

[0017] It should be noted that the lubricating oil compositions of this invention comprise defined individual, *i.e.,* separate, components that may or may not remain the same chemically before and after mixing. Thus, it will be understood that various components of the composition, essential as well as optional and customary, may react under the conditions of formulation, storage or use, and that the invention also provides the product obtainable or obtained as a result of

any such reaction.

[0018] The features of the present invention will now be discussed in more detail.

Lubrication Oil Composition

[0019] The amount of phosphorus, sulfur or boron in the lubricating oil composition is measured according to ASTM D5185.

[0020] The amount of phosphorus in the lubricating oil composition, independent of the amount of sulfur or boron, with respect to the first or fourth aspect of the invention is preferably less than 550, more preferably less than 500, such as less than 400, especially less than 300 or 200, advantageously less than 100, ppm based on the mass of the oil composition. More preferably, it is zero.

[0021] The amount of phosphorus in the lubricating oil composition, independent of the amount of sulfur or boron, with respect to the second, fifth, seventh, or ninth aspect of the invention is preferably less than 800 or 700, more preferably less than 600 or 550, such as less than 500 or 400, especially less than 300 or 200, advantageously less than 100, ppm based on the mass of the oil composition. More preferably, it is zero.

[0022] The amount of phosphorus in the lubricating oil composition, independent of the amount of sulfur or boron, with respect to the third or sixth aspect of the invention is preferably less than 700, more preferably less than 600 or 550, such as less than 500 or 400, especially less than 300 or 200, advantageously less than 100, ppm based on the mass of the oil composition. More preferably, it is zero.

[0023] The amount of sulfur in the lubricating oil composition, independent of the amount of phosphorus or boron, with respect to each aspect of the invention is preferably at most 5000 or 4000, or at most 3000 or 2500, ppm by mass, based on the mass of the oil composition; especially it is at most 2000, or at most 1500, ppm by mass; advantageously it is less than 1000, or less than 700, ppm. More preferably, it is zero.

[0024] Typically, the phosphorus in the oil composition is derived from a phosphorus-containing additive, such as a ZDDP that may be present. The sulfur can be derived from the oil of lubricating viscosity, such as Group 1, II or III basestock; the diluent oil or carrier oil, which is used as a carrier fluid for the additive components and additive compositions; and any sulfur-containing additives, for example, ZDDPs and sulfonate detergents. In an embodiment of each aspect of the present invention, the defined amount of phosphorus is in respect of the amount of phosphorus derived from ZDDP that is present.

[0025] The amount of boron, independent of the amount of sulfur or phosphorus, with respect to the first or fourth aspect is preferably greater than 250, for example, greater than 300, ppm based on the mass of the oil composition; more preferably the amount of boron is greater than any one of 400, 500, 600, 700, 800 or 900, ppm; especially the amount of boron is greater than any one of 1000, 1100, 1200 or 1500, ppm. Advantageously the amount of boron does not exceed 2000 ppm, based on the mass of the oil composition.

[0026] The amount of boron, independent of the amount of sulfur or phosphorus, with respect to the second or fifth aspect is preferably greater than 350, for example, greater than 400, ppm based on the mass of the oil composition; more preferably the amount of boron is greater than any one of 500, 600, 700, 800 or 900, ppm; especially the amount of boron is greater than any one of 1000, 1100, 1200 or 1500, ppm. Advantageously the amount of boron does not exceed 2000 ppm, based on the mass of the oil composition.

[0027] The amount of boron, independent of the amount of sulfur or phosphorus, with respect to the third, sixth, seventh or ninth aspect is preferably greater than 100, for example, greater than 200, ppm based on the mass of the oil composition; more preferably the amount of boron is greater than any one of 300, 400, 500, 600, 700, 800 or 900, ppm; especially the amount of boron is greater than any one of 1000, 1100, 1200 or 1500, ppm. Advantageously the amount of boron does not exceed 2000 ppm, based on the mass of the oil composition.

[0028] Typically, the boron in the oil composition is derived from a boron-containing additive.

[0029] In an embodiment of each aspect of the invention, one or more of a zinc dithiocarbamate and a copper-containing compound are substantially absent.

[0030] In an embodiment of each aspect of the invention, a molybdenum-containing additive, for example a molybdenum dithiocarbamate is present in the oil composition, then the amount of molybdenum in the oil composition is at most 400, preferably 300, such as 200, especially 100, ppm by mass based on the mass of the oil composition.

[0031] In a preferred embodiment of each aspect of the invention, the lubricating oil composition has less than 1.5, especially less than 1.3, such as in the range from 0.01 to 0.5, mass % of sulfated ash, according to the method ASTM D874.

[0032] Preferably, the lubricating oil composition is a multigrade identified by the descriptor SAE 5W-20 or SAE 5W-30, whose properties are defined in the Society of Automotive Engineers document SAE J300.

Oil of Lubricating Viscosity

[0033] The oil of lubricating viscosity or lubricating oil can be a synthetic or mineral oil of lubricating viscosity selected from the group consisting of Group I, II, III, IV and V basestocks, and a mixture containing any two or more thereof.

[0034] Basestocks may be made using a variety of different processes including but not limited to distillation, solvent refining, hydrogen processing, oligomerization, esterification, and rerefining.

[0035] API 1509 "Engine Oil Licensing and Certification System" Fourteenth Edition, December 1996 states that all basestocks are divided into five general categories:

Group I basestocks contain less than 90% saturates and/or greater than 0.03% sulfur and have a viscosity index greater than or equal to 80 and less than 120;

Group II basestocks contain greater than or equal to 90% saturates and less than or equal to 0.03% sulfur and have a viscosity index greater than or equal to 80 and less than 120;

Group III basestocks contain greater than or equal to 90% saturates and less than or equal or 0.03% sulfur and have a viscosity index greater than or equal to 120;

Group IV basestocks contain polyalphaolefins (PAO); and

Group V basestocks contain include all other basestocks not included in Group I, II, III or IV.

[0036] Group IV basestocks, *i.e.,* polyalphaolefins (PAO), include hydrogenated oligomers of an alpha-olefin, the most important methods of oligomerization being free radical processes, Ziegler catalysis, cationic and Friedel-Crafts catalysis.

[0037] Preferably the lubricating oil is selected from any one of Group I to V basestocks and mixtures thereof.

[0038] Especially preferred is any one of Group II, III, IV or V basestock or a mixture containing any two or more thereof, or a mixture of Group IV basestock with 5 to 80 mass % of Group I, II, III or V basestock.

[0039] The test methods used in defining the above groups are ASTM D2007 for saturates; ASTM D2270 for viscosity index; and one of ASTM D2622, 4294, 4927 and 3120 for sulfur.

Boron-Containing Additive

[0040] Boron-containing additives may be prepared by reacting a boron compound with an oil-soluble or oil-dispersible additive or compound. Boron compounds include boron oxide, boron oxide hydrate, boron trioxide, boron trifluoride, boron tribromide, boron trichloride, boron acid such as boronic acid, boric acid, tetraboric acid and metaboric acid, boron hydrides, boron amides and various esters of boron acids.

[0041] Examples of boron-containing additives include a borated dispersant; a borated dispersant VI improver; an alkali metal or a mixed alkali metal or an alkaline earth metal borate; a borated overbased metal detergent; a borated epoxide; a borate ester; and a borate amide.

[0042] Borated dispersants may be prepared by boration of succinimide, succinic ester, benzylamine and their derivatives, each of which has an alkyl or alkenyl group of molecular weight of 700 to 3000. Processes for manufacture of these additives are known to those skilled in the art. A preferred amount of boron contained in these dispersants is 0.1 to 5 mass % (especially 0.2 to 2 mass %). A particularly preferable borated dispersant is a succinimide derivative of boron, for example borated polyisobutenyl succinimide.

[0043] Alkali metal and alkaline earth metal borates are generally hydrated particulate metal borates, which are known in the art. Alkali metal borates include mixed alkali and alkaline earth metal borates. These metal borates are available commercially. Representative patents describing suitable alkali metal and alkaline earth metal borates and their methods of manufacture include U.S. 3,997,454; 3,819,521; 3,853.772; 3,907,601; 3,997,454; and 4,089,790.

[0044] Boron-containing additives include borated fatty amines. The borated amines maybe prepared by reacting one or more of the above boron compounds with one or more of fatty amines, e.g., an amine having from four to eighteen carbon atoms. They may be prepared by reacting the amine with the boron compound from 50 to 300, preferably from 100 to 250 at a temperature in the range of °C and at a ratio from 3:1 to 1:3 equivalents of amine to equivalents of boron compound.

[0045] Borated fatty epoxides are generally the reaction product of one or more of the above boron compounds with at least one epoxide. The epoxide is generally an aliphatic epoxide having from 8 to 30, preferably from 10 to 24, more preferably from 12 to 20, carbon atoms. Examples of useful aliphatic epoxides include heptyl epoxide and octyl epoxide. Mixtures of epoxides may also be used, for instance commercial mixtures of epoxides having from 14 to 16 carbon

atoms and from 14 to 18 carbon atoms. The borated fatty epoxides are generally known and are described in U.S. Patent 4,584,115.

[0046] Borate esters may be prepared by reacting one or more of the above boron compounds with one or more alcohols of suitable oleophilicity. Typically, the alcohols contain from 6 to 30, or from 8 to 24, carbon atoms. The methods of making such borate esters are known in the art.

[0047] The borate esters can be borated phospholipids. Such compounds, and processes for making such compounds, are described in EP-A-0 684 298.

[0048] Borated overbased metal detergents are known in the art where the borate substitutes the carbonate in the core either in part or in full.

[0049] A preferred boron-containing additive is a borated polyisobutenyl succinimide wherein the average number molecular weight ($\overline{M}n$) of the polybutenyl backbone is in the range from 700 to 1250.

Detergent Additive Composition

[0050] In appropriate aspects of the invention, for example the first, second, fourth, fifth, seventh, and ninth aspects, a detergent additive composition, which comprises one or more detergents, may be provided in the lubricating oil composition.

[0051] A detergent is an additive that reduces formation of piston deposits, for example high-temperature varnish and lacquer deposits, in engines; it has acid-neutralising properties and is capable of keeping finely divided solids in suspension. It is usually based on metal "soaps", that is metal salts of acidic organic compounds, sometimes referred to as surfactants. Organic acids useful in present invention typically have one or more functional groups, such as OH or COOH or SO_3H, and a hydrocarbyl substituent. Examples of organic acids include sulfonic acids, phenols and sulfurised derivatives thereof, and carboxylic acids. The metal detergent may be neutral or overbased, which terms are known in the art.

[0052] The detergent additive composition may comprise one or more neutral detergents or one or more overbased detergents or a mixture thereof.

[0053] The metals are preferably selected from Group 1 and Group 2 metals, e.g., sodium, potassium, lithium, calcium, and magnesium.

[0054] Preferably the detergent additive composition, in respect of each aspect of the invention, comprises a metal salt of an aromatic carboxylic acid, for example a salicylate-based detergent, such as calcium salicylate. It is particularly preferred that the detergent additive composition comprises more than 50 mole % of a metal salt of an aromatic carboxylic acid, based on the moles of the metal salts of organic acids in the detergent composition. More preferably the proportion of the metal salt of an aromatic carboxylic acid is at least 60 or at least 70 mole %; more preferably at least 80 or at least 90 mole %, based on the moles of the metal salts of organic acids in the detergent additive composition.

[0055] In a most preferred embodiment, the detergent additive composition comprises 100 mole % of a metal salt of an aromatic carboxylic acid, based on the moles of the metal salts of organic acids in the detergent composition, that is the detergent additive composition comprises only aromatic carboxylic acids as the organic acids.

[0056] Preferred examples of aromatic carboxylic acids are salicylic acids and sulphurised derivatives thereof, such as hydrocarbyl substituted salicylic acid and derivatives thereof. Especially preferred are salicylic acids.

[0057] With respect to any one of the first, second, fourth, fifth, seventh or ninth aspect, in an embodiment, the detergent additive composition comprises one or more detergents of the same metal, for example calcium or magnesium, preferably calcium; more preferably the detergents are of different surfactant types, such as calcium salicylate and calcium sulfonate. In another embodiment, the detergent additive composition comprises at least two detergents of at least different two metals, for example a neutral or overbased magnesium detergent and at least one other metal detergent, or a neutral or overbased calcium detergent and/or neutral or overbased sodium detergent.

[0058] Preferred detergent additive compositions in respect of each aspect of the invention comprise a mixture of calcium and magnesium detergents.

[0059] Detergent additive compositions comprising only salicylate detergents, whether neutral or overbased, are particularly advantageous.

[0060] Surfactants that may also be used include aliphatic carboxylates; sulfonates; phenates, non-sulfurised or sulfurised; thiophosphonates; and naphthenates.

[0061] Also suitable in each aspect of the present invention is a detergent in the form of a hybrid complex detergent, wherein the basic material is stabilised by more than one type of surfactant. It will be appreciated by one skilled in the art that a single type of organic acid may contain a mixture of organic acids of the same type. For example, a sulphonic acid may contain a mixture of sulphonic acids of varying molecular weights. Such an organic acid composition is considered as one type. Thus, complex detergents are distinguished from mixtures of two or more separate overbased detergents, an example of such a mixture being one of an overbased calcium salicylate detergent with an overbased calcium phenate detergent.

[0062] The art describes examples of overbased complex detergents. For example, International Patent Application Publication Nos. 9746643/4/5/6 and 7 describe hybrid complexes made by neutralising a mixture of more than one acidic organic compound with a basic metal compound, and then overbasing the mixture.

[0063] Individual basic micelles of the detergent are thus stabilised by a plurality of surfactant types.

[0064] EP-A-0 750 659 describes a calcium salicylate phenate complex made by carboxylating a calcium phenate and then sulfurising and overbasing the mixture of calcium salicylate and calcium phenate. Such complexes may be referred to as "phenalates"

[0065] The proportion of one surfactant to another in a complex detergent is not critical.

[0066] Preferred complex detergents are salicylate-based detergents, for example, "phenalates".

[0067] The detergents, whether complex or not, can have a Total Base Number (TBN) in the range of 15 or 60 to 600, preferably 100 to 450, more preferably 160 to 400.

[0068] When the detergent additive composition consists of metal salicylate detergents, it is preferred that the salicylate is either calcium salicylate or a mixture of calcium and magnesium salicylates. More preferably, at least one or each metal salicylate detergent is overbased. When both calcium and magnesium salicylates are present, more calcium salicylate than magnesium salicylate can be present, based on the mass of the respective metals.

[0069] When the detergent additive composition comprises two or more metal detergents of different surfactant types, it is preferred that the detergents have the same metal, for example, calcium.

[0070] As an example, the total amount of metal derived from the metal detergents in the lubricating oil composition is at most 2700 ppm, based on the mass of the oil composition.

[0071] Further co-additives may be present to meet particular requirements. Examples of such include viscosity index improvers, corrosion inhibitors, detergents other than those mentioned, metal rust inhibitors, pour point depressants, anti-foaming agents, dispersants other than those mentioned, anti-wear agents, oxidation inhibitors or anitoxidants, and friction modifiers.

[0072] In respect of appropriate aspects of the invention, for example, the fourth, fifth and sixth aspects, the preparation of an additive composition is a convenient method of adding the additives to a lubricating oil in order to yield a lubricating oil composition. The amount of additives in the oil composition is preferably in the range from 5 to 9, especially from 6 to 8, mass % based on the mass of the oil composition.

[0073] The present invention is illustrated by, but in no way limited to, the following examples.

EXAMPLES

Compositions

[0074] Four crankcase lubricating oil compositions, each satisfying the 5W30 viscosity grade, were prepared by methods known in the art. Two, Examples 1 and 2, are examples of the invention, and two, Examples A and B, are comparative examples. The compositional details of the examples are tabulated below.

Elemental Content (ppm by mass)	1	2	A	B
Boron[1]	1180	770	1	0
Phosphorus[2]	0	0	0	500
Sulfur[3]	620	630	690	1505
Calcium[4]	2220	2240	2260	2370
Magnesium[5]	380	380	390	380

[0075] The sulfated ash content of each composition is on or about 1 mass %.

[0076] Key

1 = derived from borated dispersant
2 = derived from ZDDP
3 = derived from diluent or carrier oil and basestock; and in Example B, also from ZDDP.
4 = derived from calcium salicylate detergent
5 = derived from magnesium salicylate detergent

[0077] In all other relevant respects, the four compositions are comparable.

Tests and Results

[0078] Each composition was tested for its wear performance in the Peugeot TU3M Scuffing Test, according to CEC-L-38-A-94, and Sequence IVA Test, according to RR:D02-1473.
The results are tabulated below.

	Comparative Examples		Examples	
	A	B	1	2
Peugeot TU3				
Pad Merit (Limit – 7.5 min.)	2.5	6.8	9	7.5
Cam Average (Limit – 10 max.)	65	4.1	5.8	4.9
Cam Maximum (Limit – 15 max.)	97.5	5.5	8.5	6.3
Overall Result	**Fail**	**Fail**	**Pass**	**Pass**
Sequence IVA				
Cam Average (Limit – 120 max.)	409.17	169.43	43.77	42.54
Overall Result	**Fail**	**Fail**	**Pass**	**Pass**

[0079] They show that superior wear results are obtained by inclusion of boron at broadly similar sulfur levels and in the absence of phosphorus, *i.e.,* comparing the results for Examples 1 and 2 with those for Example A. They also show that inclusion of boron gives rise to better overall wear results than a boron-free composition containing higher levels of both phosphorus and sulfur, i.e. comparing the results for Examples 1 and 2 with those for Example B.

Claims

1. A crankcase lubricating oil composition comprising, or made by admixing, an oil of lubricating viscosity, in a major amount, and, in respective minor amounts, a boron-containing additive and one or more co-additives, wherein the lubricating oil composition has greater than 200 ppm by mass of boron, less than 600 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition.

2. A crankcase lubricating oil composition comprising, or made by admixing, an oil of lubricating viscosity, in a major amount, and, in respective minor amounts, a boron-containing additive and one or more co-additives, wherein the lubricating oil composition has greater than 300 ppm by mass of boron, less than 900 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition.

3. A crankcase lubricating oil composition comprising, or made by admixing, an oil of lubricating viscosity, in a major amount, and, in respective minor amounts, a boron-containing additive, a detergent additive composition and one or more co-additives, wherein the lubricating oil composition has greater than 50 ppm by mass of boron, less than 800 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition, provided that the detergent additive composition comprises at least two detergents of at least two metals.

4. The composition as claimed in any one of the preceding claims in the form of a SAE 5W-20 or 5W-30 composition.

5. The composition as claimed in any one of claims 1, 2 or 4, wherein the oil composition further comprises, or is made by admixing, a detergent additive composition, in a minor amount, comprising at least two detergents of at least two metals.

6. The composition as claimed in any one of claims 1 to 5 containing a salicylate-based detergent, in a minor amount.

7. The composition as claimed in any one of claims 1 to 6 wherein the ash content of the composition is less than

1.5 mass % based on the mass of the composition, as measured according to ASTM D-874.

8. An additive composition comprising, or made by admixing, a diluent or carrier oil, a boron-containing additive and one or more co-additives in such proportions so to provide a crankcase lubricating oil composition having greater than 200 ppm of boron, less than 600 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition, when the oil composition contains 4 to 10 mass % of the additives.

9. An additive composition comprising, or made by admixing, a diluent or carrier oil, a boron-containing additive and one or more co-additives in such proportions so to provide a crankcase lubricating oil composition having greater than 300 ppm of boron, less than 900 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition, when the oil composition contains 4 to 10 mass % of the additives.

10. An additive composition comprising, or made by admixing, a diluent or carrier oil, a boron-containing additive, a detergent additive composition comprising at least two detergents of at least two metals and one or more co-additives in such proportions so to provide a crankcase lubricating oil composition having greater than 50 ppm by mass of boron, less than 800 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition, when the oil composition contains 4 to 10 mass % of the additives.

11. A method for conferring wear resistance to a crankcase lubricating oil composition that contains less than 900 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition, by provision in the composition of a boron-containing additive to provide greater than 50 ppm by mass of boron based on the mass of the composition.

12. A method of lubricating the crankcase of a spark-ignited or a compression-ignited internal combustion engine which comprises supplying to the engine a lubricating oil composition as claimed in any one of claims 1 to 7.

13. The use of an effective amount of a boron-containing additive in a crankcase lubricating oil composition that contains less than 900 ppm by mass of phosphorus and less than 6000 ppm by mass of sulfur, based on the mass of the oil composition, to provide wear resistance.

European Patent Office

DECLARATION

which under Rule 45 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number EP 01 30 9510

The Search Division considers that the present application, does not comply with the provisions of the EPC to such an extent that it is not possible to carry out a meaningful search into the state of the art on the basis of all claims

Reason:

There is an exaggerated number of independent claims (claims 1,2,3,8,9,10,11,12,13) making impossible the definition of the scope of the claimed invention.

The subject-matter of the claims is defined exclusively by the result to be achieved and not by the technical features which lead to this result.

The applicant's attention is drawn to the fact that a search may be carried out during examination following a declaration of no search under Rule 45 EPC, should the problems which led to the declaration being issued be overcome (see EPC Guideline C-VI, 8.5).

CLASSIFICATION OF THE APPLICATION (Int.Cl.7)

C10M141/12

Place of search	Date	Examiner
MUNICH	28 February 2002	Perakis, N

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