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(54) Titre : COMPOSITIONS D'HUILES LUBRIFIANTES
(54) Title: LUBRICATING OIL COMPOSITIONS

(57) Abrégé/Abstract:
A heavy duty diesel engine lubricating oil composition comprising, or made by admixing: (A) a major amount of an oil of lubricating viscosity comprising at feast 35 mass % of a Group III basestock, based on the mass of the oil of lubricating viscosity, that contains at most 0.03 mass % of sulfur, based on the mass of the basestock, and that has a viscosity index of 120 or greater and has greater than or equal to 90 mass % saturates, based on the mass of said basestock; and (B) a minor amount of an additive composition comprising : (i) a detergent composition; and (ii) one or more other additives; wherein the oil composition has a cold cranking simulated viscosity, measured according to ASTM D2602, of less than 7000 mPa.s at -25°C and a sulfated ash, measured according to ASTM D874, of less than 1.35 mass %, based on the mass of the oil composition. The oil compositions provide improved piston cleanliness of a heavy duty diesel engine.

ABSTRACT

A heavy duty diesel engine lubricating oil composition comprising, or made by admixing:

(A) a major amount of an oil of lubricating viscosity comprising at least 35 mass % of a Group III basestock, based on the mass of the oil of lubricating viscosity, that contains at most 0.03 mass % of sulfur, based on the mass of the basestock, and that has a viscosity index of 120 or greater and has greater than or equal to 90 mass % saturates, based on the mass of said basestock; and

(B) a minor amount of an additive composition comprising :

(i) a detergent composition; and

(ii) one or more other additives;

wherein the oil composition has a cold cranking simulated viscosity, measured according to ASTM D2602, of less than 7000 mPa.s at -25ºC and a sulfated ash, measured according to ASTM D874, of less than 1.35 mass %, based on the mass of the oil composition. The oil compositions provide improved piston cleanliness of a heavy duty diesel engine.

LUBRICATING OIL COMPOSITIONS

The present invention concerns lubricating oil compositions for lubricating the crankcase of engines, particularly compression-ignited engines, such as heavy duty diesel engines, for example, engines found in road trucks.

Lubrication of the crankcase of internal combustion engines is necessary to maintain the performance and expected life-time of the engine, for example by keeping the engine as clean as possible.

The heavy duty trucking market employs the diesel engine as its preferred power source due to its excellent longevity, and specialised lubricants have been developed to meet the more stringent performance requirements of such heavy duty diesel engines than passenger car engines.

It has been found that viscous lubricating oil compositions tend to provide better engine cleanliness than less viscous lubricating oil compositions: this is particularly evident in the OM441LA engine test, where piston cleanliness is assessed on two grooves on the piston.

A potential means of improving the cleanliness effect of oil compositions is to include detergent additives, such as calcium or magnesium sulfonate and phenate, which are believed to improve engine cleanliness. However, regulations aimed at reducing environmental pollution caused by exhaust gas components, such as particulates and nitrogen oxides (NO_x), are driving lubricating oil compositions to lower sulfated ash, and therefore, to a reduced amount of detergents. This is because metal-containing additives, such as metal detergents, zinc compounds and molybdenum compounds, contribute to the amount of sulfated ash.

It has been surprisingly found that satisfactory piston cleanliness can be achieved for lubricating oil compositions that are less viscous and contain a reduced amount of detergent additives.

Accordingly, in a first aspect, the present invention provides a heavy duty diesel engine lubricating oil composition comprising, or made by admixing:

(A) a major amount of an oil of lubricating viscosity comprising at least 35 mass % of a Group III basestock, based on the mass of the oil of lubricating viscosity, that contains at most 0.03 mass % of sulfur, based on the mass of said basestock, and that has a viscosity index of 120 or greater and has greater than or equal to 90 mass % saturates, based on the mass of said basestock; and

(B) a minor amount of an additive composition comprising :

(i) a detergent composition; and

(ii) one or more other additives;

wherein the oil composition has a cold cranking simulated viscosity, measured according to ASTM D2602, of less than 7000 mPa.s at -25ºC and a sulfated ash, measured according to ASTM D874, of less than 1.35 mass %, based on the mass of the oil composition.

In a second aspect, the present invention provides a method of lubricating a heavy duty diesel engine, which engine has a total displacement of at least 6.5 litres and a displacement per cylinder of at least 1.0 litre per cylinder, which method comprises supplying to the engine a lubricating oil composition as defined in the first aspect.

In a third aspect, the present invention provides a combination of a heavy duty diesel engine, which engine has a total displacement of at least 6.5 litres and a displacement per cylinder of at least 1.0 litre per cylinder and a lubricating oil composition as defined in the first aspect.

In a fourth aspect, the present invention provides the use of an oil of lubricating viscosity comprising at least 35 mass % of a Group III basestock, based on the mass of the oil of lubricating viscosity, that contains at most 0.03 mass % of sulfur, based on the mass of said basestock, and that has a viscosity index of 120 or greater and has greater than or equal to 90 mass % saturates, based on the mass of said basestock, in a lubricating oil composition for improving the piston cleanliness of an engine.

In a fifth aspect, the present invention provides a method of improving the piston cleanliness of an engine, particularly in the OM441LA test, by adding to the engine a lubricating oil composition as defined in the first aspect.

In a sixth aspect, the present invention provides a heavy duty diesel engine lubricating oil composition giving at least 25 piston cleanliness merit points and not greater than 4 % boost pressure loss in the OM441LA engine test, according to the CEC-L-52-T-97 procedure, which oil composition comprises, or is made by admixing:

(A) a major amount of an oil of lubricating viscosity; and

(B) a minor amount of an additive composition comprising :
(i) a detergent composition; and
(ii) one or more other additives;

wherein the oil composition has a cold cranking simulated viscosity, measured according to ASTM D2602, of less than 7000 mPa.s at -25ºC and a sulfated ash, measured according to ASTM D874, of less than 1.35 mass %, based on the mass of the oil composition.

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. In the instance the term “comprising” or comprises” is used herein, the term “consisting essentially of” and its cognate are within its scope and are a preferred embodiment of it, and consequently the term “consisting of” and its cognate are within the scope of “consisting essentially of” and are a preferred embodiment of it.

“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.

The abbreviation SAE stands for Society of Automotive Engineers.

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

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.

Also, it should be noted that when the specification refers to a lubricating oil composition having a defined amount of sulfated ash, this means that the oil composition gives the defined amount of sulfated ash under ASTM D874.

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

HEAVY DUTY DIESEL ENGINES

Heavy duty diesel engines according to the present invention are preferably used in land-based vehicles, more preferably large road vehicles, such as large trucks. The road vehicles typically have a weight greater than 12 tonnes. The engines used in such vehicles tend to have a total displacement of at least 6.5, preferably at least 8, more preferably at least 10, such as at least 15, litres; engines having a total displacement of 12 to 20 litres are preferred. Generally, engines having a total displacement greater than 24 litres are not considered land-based vehicles. The engines according to the present invention also have a displacement per cylinder of at least 1.0 or at least 1.5, such as at least 1.75, preferably at least 2, litres per cylinder. Generally, heavy duty diesel engines in road vehicles have a displacement per cylinder of at most 3.5, such as at most 3.0; preferably at most 2.5, litres per cylinder. The term “heavy duty” in relation to internal combustion engines is known in the art: see ASTM D4485 at §3.17 where heavy duty engine operation is characterised by average speeds, power outputs and internal temperatures that are generally close to potential maximums; therefore, a heavy duty diesel engine is considered to operate generally under such conditions.

As used herein, the terms ‘total displacement’ and ‘displacement per cylinder’ are known to those skilled in the art of internal combustion engines (see “Diesel Engine Reference Book”, edited by B. Challen and R. Baranescu, second edition, 1999, published by SAE International). Briefly, the term "displacement' corresponds to the volume of the cylinder in the engine as determined by the piston movement and consequently the "total displacement" is the total volume dependent on the number of cylinders; and the term 'displacement per cylinder' is the ratio of the total displacement to the number of cylinders in the engine.

LUBRICATING OIL COMPOSITION

The present invention particularly concerns multigrade lubricating oil compositions (also known as multigrade lubricants) that tend to be less viscous. The SAE J300 classification defines the lubricants according to their viscometric properties, such as their maximum low temperature cranking and pumping viscosities and maximum and minimum kinematic viscosities at 100 ºC.

Preferably, the lubricating oil compositions, in each aspect of the present invention, have a low temperature cranking viscosity or cold cranking simulated viscosity, independently of the amount of sulfated ash, as measured by ASTM D2602, of less than 6000 mPa.s at –30 ºC, more preferably less than 6200 mPa.s at –35 ºC.

Preferably, the lubricating oil compositions, in each aspect of the present invention, have a sulfated ash, independently of the cold cranking simulated viscosity, as measured by ASTM D874, of less than 1.25 or 1.15, more preferably less than any of 1.05, 1.00, and 0.95, such as less than 0.90, especially less than 0.85, advantageously less than 0.75, mass %, based on the mass of the oil composition. The sulfated ash can be in the range from 0 to 0.5 mass %.

In a preferred embodiment, the amount of sulfated ash, as defined above, is derived from metal-containing additives only, more preferably the sulfated ash is derived from metal detergents only, such as a calcium detergent and/or a magnesium detergent.

Preferably, the lubricating oil compositions, in each aspect of the present invention, have a TBN of less than 11.2 or 10.5 or 9.8, preferably less than any one of 9.2, 8.8 and 8.5, especially less than 7.8, advantageously less than 7. 1. The TBN can be in the range from 2.1 to 5.5.

Preferably, the lubricating oil compositions, in each aspect of the present invention, have a metal content, whether transition metal or alkaline earth metal or alkali metal, of less than 4800 or 4400 or 4000, more preferably less than any of 3700, 3500 and 3300, especially less than 3000, advantageously less than 2600, ppm. The metal content can be in the in the range from 0 to 1800 ppm.

Test methods for measuring metal content are well known to those skilled in the art.

In an embodiment of each aspect of the present invention, lubricating oil compositions of the present invention have a maximum kinematic viscosity at 100 ºC, independently of the cold cranking simulated viscosity and the amount of sulfated ash, of less than 21.9 mm^2s; preferably less than 16.3 mm^2s; such as less than 12.5 mm^2s; especially less than 9.3 mm^2s. The kinematic viscosity at 100 ºC can be, for example, in the range of 16.3 to less than 21.9; preferably in the range of 12.5 to less than 16.3; more preferably in the range of 9.3 to less than 12.5; such as in the range of 5.6 to less than 9.3.

Accordingly, the lubricating oil compositions of the present invention are multigrade oil compositions having a viscosmetric grade of an SAE 10W-X or an SAE 5W-X or OW-X, where X represents any one of 20, 30, 40 and 50, preferably X is 20 or 30 or 40, more preferably X represents 40.

The American Petroleum Institute (API), Association des Constructeur Europeén d'Autombile (ACEA) and Japanese Standards Organisation (JASO) specify the performance level required for lubricating oil compositions. Also there are performance specifications known as Global, which contain tests and performance levels from the ACEA, API and JASO specifications.

Thus, a heavy duty lubricating oil composition of the present invention preferably satisfies at least the performance requirements of heavy duty diesel engine lubricants, such as at least the API CG-4; preferably at least the API CH-4; especially at least the API CI-4. In another embodiment, the lubricating oil composition of the invention, independently of meeting the API performance requirements, preferably satisfies, in particular relating to piston cleanliness, at least the ACEA E2-96; more preferably at least the ACEA E3-96; advantageously at least the ACEA E5-99; and especially at least ACEA E4-99. In a further embodiment, the lubricating oil composition of the invention, independently of meeting the API and ACEA performance requirements, preferably satisfies the JASO DH-1 or Global DHD-1.

Oil of Lubricating Viscosity

The oil of lubricating viscosity is the major liquid constituent of a lubricating oil composition. The oil of lubricating viscosity includes (a) oil added to a concentrate or additive package, and (b) any oil present in a concentrate or additive package.

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.

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

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 are polyalphaolefins (PAO); and

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

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.

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.

Group V basestocks in the form of esters are preferred and are also commercially available. Examples include polyol esters such as pentaerythritol esters, trimethylolpropane esters and neopentylglycol esters; diesters; C_{36} dimer acid esters; trimellitate esters, *i.e.* 1, 2, 4-benzene tricarboxylates; and pthalate esters, *i.e.* 1,2 – benzene dicarboxylates. The acids from which the esters are made are preferably monocarboxylic acids of the formula RCO_2H where R represents a branched, linear or mixed alkyl group. Such acids may, for example, contain 6 to 18 carbon atoms

The oil of lubricating viscosity of the first aspect, and preferably of the sixth aspect, comprises at least 35 mass % of a Group III basestock, based on the mass of the oil of lubricating viscosity, that contains at most 0.03 mass % of sulfur, based on the mass of said basestock, and that has a viscosity index of 120 or greater and has greater than or equal to 90 mass % saturates, based on the mass of said basestock.

Preferably, the oil of lubricating viscosity comprises said basestock in an amount of at least 40, more preferably at least 45, such as at least 50, especially in the range of 55 to 95, advantageously from 65 to 90, for example 70 to 80 or 85, mass %, based on the mass of the oil of lubricating viscosity. For the avoidance of doubt, the oil of lubricating viscosity includes the basestock that arise from the provision of additive components in the oil composition.

In a preferred embodiment, the defined proportion of said basestock is that added to the concentrate or additive package.

In the instance the oil of lubricating viscosity comprises a mixture of basestock Groups, it is preferred that a Group I basestock and a Group III basestock are present.

In a preferred embodiment, the oil of lubricating viscosity consists essentially of a Group III basestock and one or more of a Group IV basestock and a Group V basestock in the form of an ester, and optionally a minor amount of those basestocks that arise from the provision of additive components in the oil composition.

Additive Composition

In each aspect of the present invention, an additive composition comprises a detergent composition and one or more other additives, which may include other metal-containing additives, such as zinc dithiophosphates.

A detergent composition contains a detergent. 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 based on metal "soaps", that is metal salts of organic acids, also known as surfactants herein.

A detergent comprises a polar head, *e.g.* the metal salt of the organic acid, with a long hydrophobic tail for oil solubility. Therefore, the organic acids 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, salicylic acids and sulfurised derivatives thereof; and carboxylic acids.

The detergents of the present invention can comprise metal salts of an organic acid and particles of basic inorganic salts (*e.g.* calcium carbonate particles).

Thus, each or the metal detergent in the detergent composition may be neutral or overbased, such terms are understood by those skilled in the art.

A detergent composition comprising one or more metal salts of organic acids may be present, for example, a mixture of metal sulfonate and metal phenate.

The detergents of the present invention may be salts of one type of organic acid or salts of more than one type of organic acids, for example hybrid complex detergents. Preferably, they are salts of one type of organic acid.

A hybrid complex detergent is where the basic material within the detergent is stabilised by more than one type of organic acid. 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 sulfonic acid may contain a mixture of sulfonic 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.

The art describes examples of overbased complex detergents. For example, International Patent Application Publication Nos. 97-46643/4/5/6 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. Individual basic micelles of the detergent are thus stabilised by a plurality of organic acid types. Examples of hybrid complex detergents include calcium phenate-salicylate-sulfonate detergent, calcium phenate-sulfonate detergent and calcium phenate-salicylate detergent.

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”

Preferred complex detergents are salicylate-based detergents, for example, a calcium phenate-salicylate-sulfonate detergent and “phenalates”.

A detergent, whether a 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.

For the avoidance of doubt, the detergent composition may also comprise ashless detergents, *i.e.* non-metal containing detergents.

Preferably the detergent composition comprises at least one overbased metal detergent.

Group 1 and Group 2 metals are preferred as metals in the detergents; more preferably calcium and magnesium, especially preferred is calcium.

Preferably, the amount of alkaline earth metal in the lubricating oil composition, in each aspect of the invention, is less than 3200, or 3000 or 2800, more preferably less than any of 2500, 2400 and 2300, especially less than 2000, advantageously less than 1800, ppm. The alkaline earth metal content can be in the range from 0 to 1200 ppm.

Preferably, the detergent composition is present in the oil composition, in each aspect of the invention, in an amount, based on surfactant content, of at most 50, preferably at most 30, especially at most 20, millimoles of surfactant per kilogram of the oil composition (mmol/kg). In an embodiment, the amount of detergent composition, based on surfactant content, in the oil composition is 10 to15 mmol/kg.

Means for determining the amount of surfactant are known to those skilled in the art. For example, a skilled person can calculate the amounts in the final lubricating oil composition from information concerning the amount of raw materials (e.g., organic acids) used to make the detergent(s) and from information concerning the amount of detergent(s) used in the final oil composition. Analytical methods (e.g., dialysis, metal analysis, CO2 analyis, potentiometric titration and chromatography) can also be used to determine the amounts of surfactant.

It will be appreciated by a skilled person in the art that the methods to determine the amount of metal salts of organic acids (also known as surfactants) are at best approximations and that differing methods will not always give exactly the same result; they are, however, sufficiently precise to allow the practice of the present invention.

<u>Co-additives</u>

Other additives may also be present in the oil composition of the present invention.

Co-additives suitable in the present invention include viscosity index improvers, corrosion inhibitors, oxidation inhibitors or antioxidants, dispersants, rust inhibitors or rust prevention agents, anti-wear agents, pour point depressants, demulsifiers, and anti-foaming agents.

Viscosity index improvers (or viscosity modifiers) impart high and low temperature operability to a lubricating oil and permit it to remain shear stable at elevated temperatures and also exhibit acceptable viscosity or fluidity at low temperatures. Suitable compounds for use as viscosity modifiers are generally high molecular weight hydrocarbon polymers, including polyesters, such as polymethacrylates; poly(ethylene-co-propylene) polymers and closely related modifications (so called olefin copolymers); hydrogenated poly(styrene-co-butadiene or –isoprene) polymers and modifications; and esterified poly(styrene-co-maleic anhydride) polymers . Oil-soluble viscosity modifying polymers generally have number average molecular weights of at least 15,000 to 1,000,000, preferably 20,000 to 600,000, as determined by gel permeation chromatography or light scattering methods. See the disclosure in Chapter 5 of "Chemistry & Technology of Lubricants", edited by R.M. Mortier and S.T. Orzulik, First edition, 1992, Blackie Academic & Professional.

Corrosion inhibitors reduce the degradation of metallic parts contacted by the lubricating oil composition. Thiadiazoles, for example those disclosed in US-A-2 719 125, 2 719 126 and 3 087 932 are examples of corrosion inhibitors for lubricating oils.

Oxidation inhibitors, or antioxidants, reduce the tendency of mineral oils to deteriorate in service, evidence of such deterioration being, for example, the production of varnish-like deposits on metal surfaces and of sludge, and viscosity increase. Suitable oxidation inhibitors include sulfurized alkyl phenols and alkali or alkaline earth metal salts thereof; hindered phenols; diphenylamines; phenyl-naphthylamines; and phosphosulfurized or sulfurized hydrocarbons.

Other oxidation inhibitors or antioxidants which may be used in lubricating oil compositions include oil-soluble copper compounds. The copper may be blended into the oil as any suitable oil-soluble copper compound. By oil-soluble it is meant that the compound is oil-soluble under normal blending conditions in the oil or additive package. The copper may, for example, be in the form of a copper dihydrocarbyl thio- or dithio-phosphate. Alternatively, the copper may be added as the copper salt of a synthetic or natural carboxylic acid, for example, a C_8 to C_{18} fatty acid, an unsaturated acid, or a branched carboxylic acid. Also useful are oil-soluble copper dithiocarbamates, sulfonates, phenates, and acetylacetonates. Examples of particularly useful copper compounds are basic, neutral or acidic copper Cu^{I} and/or Cu^{II} salts derived from alkenyl succinic acids or anhydrides.

Copper antioxidants will generally be employed in an amount of from about 5 to 500 ppm by weight of the copper, in the final lubricating composition.

Dispersants maintain oil-insoluble substances, resulting from oxidation during use, in suspension in the fluid, thus preventing sludge flocculation and precipitation or deposition on metal parts. So-called ashless dispersants are organic materials which form substantially no ash on combustion, in contrast to metal-containing (and thus ash-forming) detergents. Borated metal-free dispersants are also regarded herein as ashless dispersants. Suitable dispersants include, for example, derivatives of long chain hydrocarbyl-substituted carboxylic acids, in which the hydrocarbyl group has a number average molecular weight tends of less than 15,000, such as less than 5000; examples of such derivatives being derivatives of high molecular weight hydrocarbyl-substituted succinic acid. Such hydrocarbyl-substituted carboxylic acids may be reacted with, for example, a nitrogen-containing compound, advantageously a polyalkylene polyamine, or with an alcohol. Particularly preferred dispersants are the reaction products of polyalkylene amines with alkenyl succinic anhydrides. Examples of specifications disclosing dispersants of the last-mentioned type are US-A-3 202 678, 3 154 560, 3 172 892, 3 024 195, 3 024 237, 3 219 666, 3 216 936 and BE-A-662 875.

Heavy duty diesel engine lubricating oil compositions tend to have a higher amount of nitrogen, preferably derived from a dispersant, than passenger car engine oil compositions because more oil-insoluble substances, such as soot, are formed in heavy duty diesel engines. Accordingly, the nitrogen content, is preferably at least 0.06, more preferably at least 0.08, such as at least 0.10, especially at least 0.12, mass %, based on the mass of the oil composition. The amount of nitrogen, preferably derived from the dispersant, tends not to be more than 0.2 mass %. The amount of nitrogen is measured according to ASTM D4629.

Alternatively or in addition, dispersancy may be provided by polymeric compounds capable of providing viscosity index improving properties and dispersancy, such compounds are known as a multifunctional viscosity index improvers. Such polymers differ from conventional viscosity index improvers in that they provide performance properties, such as dispersancy and/or antioxidancy, in addition to viscosity index improvement.

Dispersant olefin copolymers and dispersant polymethacrylates are examples of multifunctional viscosity index improvers. Multifunctional viscosity index improvers are prepared by chemically attaching various functional moieties, for example amines, alcohols and amides, onto polymers, which polymers preferably tend to have a number average molecular weight of at least 15,000, such in the range from 20,000 to 600,000, as determined by gel permeation chromatography or light scattering methods. The polymers used may be those described above with respect to viscosity modifiers. Therefore, amine molecules may be incorporated to impart dispersancy and/or antioxidancy characteristics, whereas phenolic molecules may be incorporated to improve antioxidant properties. A specific example, therefore, is an inter-polymer of ethylene-propylene post grafted with an active monomer such as maleic anhydride and then derivatized with, for example, an alcohol or amine.

EP-A-24146 and EP-A-0 854 904 describe examples of dispersants and dispersant viscosity index improvers.

Rust inhibitors selected from the group consisting of nonionic polyoxyalkylene polyols and esters thereof, polyoxyalkylene phenols, and anionic alkyl sulfonic acids may be used.

Antiwear agents, as their name implies, reduce wear of metal parts. Zinc dihydrocarbyl dithiophosphates (ZDDPs) are very widely used as antiwear agents. Examples of ZDDPs for use in oil-based compositions are those of the formula $Zn[SP(S)(OR^1)(OR^2)]_2$ wherein R^1 and R^2 contain from 1 to 18, and preferably 2 to 12, carbon atoms.

Sulfur- and molybdenum-containing compounds are also examples of anti-wear additives. Also suitable are ashless phosphorus- and sulfur-containing compounds.

Pour point depressants, otherwise known as lube oil flow improvers, lower the minimum temperature at which the fluid will flow or can be poured. Such additives are well known. Foam control may be provided by an antifoamant of the polysiloxane type, for example, silicone oil or polydimethyl siloxane.

A small amount of a demulsifying component may be used. A preferred demulsifying component is described in EP-A-0 330 522. It is obtained by reacting an alkylene oxide with an adduct obtained by reacting a bis-epoxide with polyhydric alcohol.

Some of the above-mentioned additives may provide a multiplicity of effects; thus for example, a single additive may act as a dispersant-oxidation inhibitor. This approach is well known and need not be further elaborated herein.

Preferably an anti-wear additive, such a metal dihydrocarbyldithiophosphate, for example, zinc dihydrocarbyldithiophosphate, is present in the lubricating oil compositions of the present invention.

When lubricating compositions contain one or more of the above-mentioned additives, including the detergents, each additive is typically blended into the base oil in an amount which enables the additive to provide its desired function. Representative effective amounts of such additives, when used in lubricants, are as follows:

Additive	**Mass % a.i.* (Broad)**	**Mass % a.i.* (Preferred)**
Viscosity Modifier	0.01-6	0.01-4
Corrosion Inhibitor	0.01-5	0.01-1.5
Oxidation Inhibitor	0.01-5	0.01-1.5
Friction Reducer	0.01-5	0.01-1.5
Dispersant	0.1-20	0.1-8
Dispersant Viscosity Modifier	0.01 -5	0.05-5
Detergent	0.01-6	0.01-3
Anti-wear Agent	0.01-6	0.01-4
Pour Point Depressant	0.01-5	0.01-1.5
Rust Inhibitor	0.001-0.5	0.01-0.2
Anti-Foaming Agent	0.001-0.3	0.001-0.15
Demulsifier	0.001-0.5	0.01-0.2

* Mass % active ingredient based on the final lubricating oil composition.

The additives may be incorporated into an oil of lubricating viscosity (also known as a base oil) in any convenient way. Thus, each additive can be added directly to the oil by dispersing or dissolving it in the oil at the desired level of concentration. Such blending may occur at ambient temperature or at an elevated temperature. Typically an additive is available as an admixture with a base oil so that the handling thereof is easier.

When a plurality of additives are employed it may be desirable, although not essential, to prepare one or more additive packages (also known as additive compositions or concentrates) comprising additives and a diluent, which can be a base oil, whereby the additives, with the exception of viscosity modifiers, multifuntional viscosity modifiers and pour point depressants, can be added simultaneously to the base oil to form the lubricating oil composition. Dissolution of the additive package(s) into the oil of lubricating viscosity may be facilitated by diluent or solvents and by mixing accompanied with mild heating, but this is not essential. The additive package(s) will typically be formulated to contain the additive(s) in proper amounts to provide the desired concentration in the final formulation when the additive package(s) is/are combined with a predetermined amount of oil of lubricating viscosity. Thus, one or more detergents may be added to small amounts of base oil or other compatible solvents (such as a carrier oil or diluent oil) together with other desirable additives to form additive packages containing from 2.5 to 90, preferably from 5 to 75, most preferably from 8 to 60, mass %, based on the mass of the additive package, of additives on an active ingredient basis in the appropriate proportions. The final formulations may typically contain 5 to 40 mass % of the additive package(s), the remainder being oil of lubricating viscosity.

The amount of additives in the final lubricating oil composition is generally dependent on the type of the oil composition, for example, a heavy duty diesel engine lubricating oil composition has 2 to 20, preferably 5 to 18, more preferably 7 to 16, such as 8 to 14, mass % of additives, based on the mass of the oil composition.

Thus, a method of preparing the oil composition according to the present invention can involve admixing an oil of lubricating viscosity and one or more additives or an additive package that comprises one or more of the additives.

A means of increasing the power output of an engine, particularly a compression-ignited engine, is to include a turbocharger in its assembly. The turbo-charger enables more fuel to be burnt per given cylinder size by pressurising the intake air so that more air is charged to the cylinder.

Turbo-chargers are typically powered by the gas expelled through the exhaust, and this can lead to a loss of efficiency of the turbo-charger during the life-time of the engine because species contained in the exhaust gas deposit within the turbo-charger. It has been also discovered that lubricating oil compositions of the present invention can minimise the loss of efficiency of a turbo-charger. A method of determining the loss of efficiency is, for example, the OM441LA test, where a boost pressure loss, as a percent, is given: the higher the boost pressure loss the greater the loss of efficiency.

Examples

Lubricating oil compositions, identified herein as Examples A to D and Examples 1 to 4, were blended by methods known in the art at comparable TBN from oils of lubricating viscosity and additive concentrates. Examples A to D are comparative and Examples 1 to 4 are of the invention. Table 1 shows details of the oil of lubricating viscosity used and the physical properties of the resulting oil compositions. Comparative Example A was blended to a SAE 15W40 viscometric grade, whereas comparative Examples B to D and Examples 1 to 4 were blended to an SAE 10W40 viscometric grade.

Comparative Examples A to D and Examples 1 to 4 were tested for piston cleanliness and boost pressure loss in the OM441LA test, according to the CEC-L-52-T-97 procedure. The results are also given in Table 1.

Table 1 shows that Example A, a SAE 15W40 lubricating oil composition, provided better piston cleanliness and boost pressure loss than Example B, an oil composition containing the same additives as those in Example A but blended to a SAE 10W40 viscometric grade.

Further, the results in Table 1 show that the piston cleanliness and boost pressure loss are improved as the proportion of Group III basestock is increased in an SAE 10W40 oil composition (see Example B through to Example 4).

ACEA E5-99 performance specification sets a passing limit of at least 25 merits points for piston cleanliness and at most 4 % for boost pressure loss. Accordingly, at least about 35 mass % of a Group III basestock in an oil of lubricating viscosity may be required to meet the limits set by ACEA E5-99 in respect of the piston cleanliness and boost pressure loss.

Table 1

	Example A	Example B	Example C	Example D	Example 1	Example 2	Example 3	Example 4
Oil of lubricating viscosity								
Group 1 basestock, mass %	100	100	67	67	56	33	33	24
Group III basestock, mass %	0	0	33	33	44	67	67	76
Physical characteristics								
SAE J300 classification	15W40	10W40	10W40	10W40	10W40	10W40	10W40	10W40
Sulfated ash, mass %	1.06	1.06	1.04	1.09	1.10	1.08	1.10	1.10
Phosphorus, mass %	0.092	0.096	0.085	0.098	0.120	0.098	0.098	0.097
TBN	9.3	9.3	9.3	9.5	10.1	9.5	9.7	9.8
OM441LA Results								
Piston cleanliness, merits	26.0	12.7	21.8	14.5	30.2	31.6	32.8	29.7
Boost pressure loss at 400 hrs., %	2.7	38.9	19.1	1.5	2.1	-2.8	-1.2	-1

Each oil composition contained additives, such as a dispersant, viscosity modifier, antioxidant, zinc dithiophosphate, calcium detergent and/or magnesium detergent, in comparable amounts.

CLAIMS:

1. A heavy duty diesel engine lubricating oil composition comprising:

(A) a major amount of an oil of lubricating viscosity comprising a mixture of basestock groups having a Group I basestock and a Group III basestock present, the oil of lubricating viscosity comprising at least 35 mass % of a Group III basestock, based on the mass of the oil of lubricating viscosity; and

(B) a minor amount of an additive composition comprising:

(i) a detergent composition introducing no greater than 3200 ppm of metal into said lubricating oil composition; and

(ii) one or more other additives;

wherein the oil composition has a cold cranking simulated viscosity, measured according to ASTM D2602, of less than 7000 mPa.s at –25°C and a sulfated ash, measured according to ASTM D874, of less than 1.35 mass %, based on the mass of the oil composition.

2. A heavy duty diesel engine lubricating oil composition made by admixing:

(A) a major amount of an oil of lubricating viscosity comprising a mixture of basestock groups having a Group I basestock and a Group III basestock present, the oil of lubricating viscosity comprising at least 35 mass % of a Group III basestock, based on the mass of the oil of lubricating viscosity; and

(B) a minor amount of an additive composition comprising:

(iii) a detergent composition introducing no greater than 3200 ppm of metal into said lubricating oil composition; and

(iv) one or more other additives;

wherein the oil composition has a cold cranking simulated viscosity, measured according to ASTM D2602, of less than 7000 mPa.s at –25°C and a sulfated ash, measured according to ASTM D874, of less than 1.35 mass %, based on the mass of the oil composition.

3. The oil composition according to claim 1 or 2, wherein the detergent composition comprises a magnesium detergent additive and/or a calcium detergent additive.

4. The oil composition according to any one of claims 1 to 3, further comprising a zinc dihydrocarbyl dithiophosphate additive.

5. A method of lubricating a heavy duty diesel engine, which engine has a total displacement of at least 6.5 litres and a displacement per cylinder of at least 1.0 litre per cylinder, which method comprises supplying to the engine the lubricating oil composition as defined in any one of claims 1 to 4.

6. The use of an oil of lubricating viscosity comprising a mixture of basestock groups having a Group I basestock and a Group III basestock present, the oil of lubricating viscosity comprising at least 35 mass % of a Group III basestock, based on the mass of the oil of lubricating viscosity, in a lubricating oil composition comprising a detergent composition introducing no more than 3200 ppm of metal into the lubricating oil composition, and having a sulfated ash, measured according to ASTM D874, of less than 1.35 mass % based on the composition, for improving the piston cleanliness of an engine.

7. A method of improving the piston cleanliness of an engine by adding to the engine the lubricating oil composition as defined in any one of claims 1 to 4.

8. The use according to claim 6 wherein the engine is a heavy duty engine having a total displacement of at least 6.5 litres and a displacement per cylinder of at least 1.0 litre per cylinder.