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(54) **High performance engine lubricants formulated with Group II basestocks**

(57) Lubricant compositions are described, capable of providing high performances in internal combustion engines, comprising:

(a) from 50 to 90% by weight of Group II (API) base oils having a volatility comprised between 7.0 and 10.0% by weight and a viscosity index comprised between 110 and 119;

(b) from 10 to 50% by weight of additives selected from antioxidants, anti-wear, detergents, dispersants, viscosity index modifiers, pour point depressants, antifoaming agents, friction modifiers or friction reducers.

The use of these lubricant compositions as engine oil for automotive applications is also described.

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Description

[0001] The present invention relates to lubricants with high performance characteristics formulated with group II base-stocks for motor vehicle applications.

[0002] In particular, the present invention relates to lubricants for motor vehicles applications with high performance characteristics which include basestocks of group II in their formulation.

[0003] Lubricants for motor vehicle applications, also indicated in the following description as engine oils, consist of one or more lubricant basestocks having a suitable viscosity and an appropriate combination of additives, generally selected from the following categories of additives: detergents, dispersants, anti-wear, antioxidants, viscosity index improvers, pour point depressants, friction modifiers or friction reducers, antifoaming agents.

[0004] Engine oil is a lubricating fluid which is used in internal combustion engines and exerts the following main actions:

- it maintains the parts of the engine in reciprocal movement separate, reducing the friction on the surfaces,
- it protects from wear and corrosion,
- it removes heat,
- it keeps the engine clean from deposits deriving from degradation products when running.

[0005] As indicated above, base oils represent the main component in almost all lubricants. It is therefore evident that the quality of the engine oil or fully formulated lubricant decisively depends on the quality of the base oils.

[0006] The choice of base oil or mixture of base oils is therefore fundamental as, although many properties of lubricants are guaranteed by an adequate additivition, the nature of the basestock strongly influences the physico-chemical and rheological characteristics, as well as the performances of the end-product.

[0007] Together with traditional mineral base oils, non-conventional and synthetic bases oils, defined as such as they do not derive directly from the processing of crude oil or because they are obtained from synthesis processes, are becoming increasingly more important.

Mineral base oils

[0008] The characteristics of mineral base oils depend on the hydrocarbon composition of the crude oil, in addition to the severity of the extraction process of the aromatic compounds and deparaffination. Some general properties, typical of these base oils can however be defined. The presence of aromatic compounds creates a good solvency and a discrete resistance to oxidation thanks to the sulfurated compounds which act as natural antioxidants. Aromatic compounds, on the contrary, can give rise to polymerization products which create deposits with time. Mineral base oils have much lower low temperature characteristics than the synthetic base oils due to the high content of n-paraffins, and consequently allow the formulation of lubricants in not particularly fluid viscosity grades. Finally, they have a higher volatility than synthetic base oils which, together with the degradation caused by oxidative processes, can contribute to a more rapid deterioration of the lubricant.

Non-conventional base oils

[0009] The processes used in the production of non-conventional base oils (hydrocracking and hydroisomerization) allow to obtain a final composition of the cuts which is relatively independent of the characteristics of the crude oil of origin. The quality of these base oils is therefore higher than that of the base oils obtained from the traditional solvent cycle, with respect to which they offer the following advantages:

- lower volatility with the same viscosity (lower consumption during exercise);
- higher viscosity index (wider range of temperatures of use);
- better temperature stability (longer useful life);
- lower content of aromatic hydrocarbons (resistance to oxidation);
- low or negligible sulphur content (relevant for engine oils, due to the growing request for compatibility with exhaust gas after treatment devices).

Synthetic base oils

[0010] Polyalphaolefins (PAO) are the most widely-used group of synthetic base oils in engine oils. They are saturated hydrocarbon chains with a high branching degree. They have much better cold and volatility characteristics than the base oils deriving from solvent extraction, hydrocracking or hydroisomerization processes.

[0011] They have a low polarity and consequently a limited solvency; this can clearly cause a poor solubilization

capacity of the polar additives present in the lubricating oil and oxidation products which are formed during running.

[0012] Another group of synthetic base oils typically used in engine oils are the esters; these are polar compounds and for this reason are generally used in a mixture with PAO.

[0013] Consequently the synthetic base oils most widely used in the field of automotive lubricants are: PAO (hydrocarbon base oils from hydrogenated α -olefins) and esters. Other synthetic base oils of more limited use are: PIO (hydrocarbon base oils from hydrogenated internal olefins), polyglycols, polybutenes, alkylated aromatic compounds.

[0014] According to the API standard 1509 "Engine Oil Licensing and Certification System", November 2004 version, 15th edition, appendix E, the basestocks which are used as base oils are defined and divided into five groups according to what is indicated in the following table I.

Table I

Group	Content of saturated hydrocarbons (weight %)	Sulphur content (weight %)	Viscosity index
I	< 90	> 0.03	≥ 80 and < 120
II	≥ 90	≤ 0.03	≥ 80 and < 120
III	≥ 90	≤ 0.03	≥ 120
IV	Poly-alpha-olefins		
V	All basestocks that do not fall within groups I, II, III and IV		

[0015] The evolution of technologies, the demand for increasing energy saving and environmental compatibility in the field of mobility, the urge to upgrade raw materials and cost-effective products, has induced automobile manufacturers and international normative organizations to conceive new specifications and engine tests for product qualification which are becoming increasingly stricter and which allow the performance qualities of lubricating oils to be revealed under severe running conditions and for long distances.

[0016] Historically, some particularly significant performances evaluated with key tests for applications in the automotive field, have represented the discriminating fact in favour of the formulation of lubricating oils with synthetic-type base oils.

[0017] Each group of base oils, as previously specified, has advantages and disadvantages in relation to its specific characteristics.

[0018] A lubricating composition has now been surprisingly found, which, without using synthetic base oils, overcomes the drawbacks of the known art, solving the technical problem of finding lubricant compositions for internal combustion engines capable of providing high performances in terms of thermo-oxidative stability, engine protection and reduction in fuel consumption, therefore suitable for extended oil drain intervals and under severe running conditions.

[0019] An object of the present invention therefore relates to lubricant compositions comprising:

(a) from 50 to 90% by weight of base oils of Group II (API) having a volatility comprised between 7.0 and 10.0% by weight and a viscosity index comprised between 110 and 119;

(b) from 10 to 50% by weight of additives selected from antioxidants, anti-wear, detergents, dispersants, viscosity index modifiers, pour point depressants, antifoaming agents, friction modifiers or friction reducers.

[0020] The lubricant compositions according to the present invention preferably comprise:

(a) from 60 to 80% by weight of base oils of Group II (API) having a volatility comprised between 7.0 and 10.0% by weight and a viscosity index comprised between 110 and 119;

(b) from 20 to 40% by weight of additives selected from:

antioxidants, in an amount ranging from 0.5 to 3.0% by weight, preferably from 0.7 to 2.0% by weight;

anti-wear additives, in an amount ranging from 0.5 to 3.0% by weight, preferably from 0.7 to 2.0% by weight;

detergents, in an amount ranging from 1.5 to 5.0% by weight, preferably from 2.0 to 4.0% by weight;

dispersants, in an amount ranging from 4.0 to 12.0% by weight, preferably from 6.0 to 9.0% by weight;

pour point reducers, in an amount ranging from 0.05 to 0.5% by weight, preferably from 0.1 to 0.3% by weight;

antifoaming agents, in an amount ranging from 5 to 200 ppm by weight, preferably from 10 to 100 ppm by weight;

friction modifiers or friction reducers additives, in an amount ranging from 0.05 to 0.5% by weight, preferably from 0.1 to 0.3% by weight;

viscosity index modifiers, in an amount ranging from 5.0 to 15% by weight, preferably from 7.0 to 12.0% by weight.

[0021] The concentrations of the components expressed in weight percentage should be considered as being defined with respect to the total weight of the lubricant composition.

[0022] The volatility of base oils of Group II is determined according to the method CEC-L-40-A-93, whereas the viscosity index of the base oils of Group II (API) is determined according to the method ASTM D 2270.

[0023] The base oils of Group II (API) preferably have a volatility ranging from 7.0 to 9.0% by weight.

[0024] The base oils of Group II (API) preferably have a viscosity index ranging from 113 to 119.

[0025] A further object of the present invention relates to the use of the lubricant compositions as an automotive engine oil.

[0026] The lubricant compositions according to the present invention are capable of giving high performances in internal combustion engines, provided through suitable additivation and with the determinant contribution of hydrocarbon base oils of Group II (API classification) having specific rheological characteristics.

[0027] In particular, the lubricant compositions according to the present invention, by using hydrocarbon base oils of Group II mixed with adequate additives, have been able to effectively respond to the performance demands of extremely severe tests without resorting to the use of synthetic components.

[0028] Tests carried out, in fact, on Volkswagen engines (tests VW-T4 and VW TDI), General Motors (test Seq. IIIG), Peugeot (test TU5) and Mercedes (test M111), have confirmed the optimum characteristics of thermo-oxidative stability, detergent properties and good contribution to "Fuel Economy" of engine oils formulated with base oils of Group II, providing performance profiles typical of synthetic oils.

[0029] A SAE 10W-40 lubricating formulation (defined according to international classification criteria for engine oils SAE J300, in the edition of November 1, 2007) obtained by maximizing the use of Group II base oils, did in fact satisfy some key requirements of the specifications of normative associations and OEMs (Original Equipment Manufacturers):

ACEA A3/B4,
API SM/CF,
Volkswagen VW 502.00/505.00,
Daimler MB 229.3.

Group II base oils

[0030] Group II base oils, according to the API classification specified above, are characterized by a sulphur content lower than or equal to 300 ppm by weight, a level of saturated hydrocarbons higher than or equal to 90% by weight, and a viscosity index ranging from 80 to 120.

[0031] These basestocks typically derive from petroleum, but all oils which respect the API classification limits fall within this category, including oils of animal or vegetable origin, as well as lubricants and oil products treated with a solvent or acid, of paraffinic, naphthenic or mixed nature which can be subsequently subjected to vacuum distillation, hydrocracking, hydrotreating and/or hydrofinishing and dewaxing processes.

[0032] Group II base oils can also be mineral oils deriving from severe hydrotreating and hydrocracking treatment. In these processes mineral oils are treated under high hydrogen pressures and temperatures in the presence of catalysts. Typical process conditions include hydrogen pressures of 3,000 psi (about 200 bar), at temperatures ranging from 300°C to 400°C, on a hydrogenation catalyst. In this way, the sulphur and nitrogen are removed and the alkylene and aromatic structures of the feedstock are saturated. The product deriving from this process is a base oil with a high resistance to oxidation and a good viscosity index. Another benefit is represented by the fact that the low-molecular-weight species of the feedstock, such as waxes, can be isomerized from linear to branched structures, consequently providing the base oil with better low-temperature properties. These hydrotreated base oils can undergo further dewaxing, catalytic or conventional processes, to reduce the pour point and improve the fluidity of the product under cold conditions.

[0033] In particular, the Group II base oils contained in the lubricant compositions according to the present invention are characterized by a volatility ranging from 7.0 to 10.0% by weight (determined with the method CEC-L-40-A-93), preferably ranging from 7.0 to 9.0% by weight, and a viscosity index ranging from 110 to 119 (determined according to the method ASTM D 2270), preferably ranging from 113 to 119.

[0034] The use of Group II base oils with this combination of characteristics, very surprisingly allows performances that are usually obtained, according to the state of the art, only by using lubricating oils containing Group III or synthetic base oils.

Additives

[0035] The content of additives in a lubricating oil generally varies from a few parts per million to various percents by weight and, on the basis of their typical function, they can be classified in:

- substances whose purpose is to improve the intrinsic characteristics of base oils such as viscosity index modifiers and pour point improvers;
- substances that protect the lubricant: antioxidants;
- substances which impart new properties and protect the metallic surfaces of the engine: detergents, dispersants, friction modifiers, antiwear agents, antirust agents and corrosion inhibitors.

Viscosity index modifiers

[0036] The viscosity is the main physical property of the lubricant and is a measurement of the intermolecular interactions of the oil and therefore of its flow resistance. The viscosity of the lubricant tends to diminish with an increase in temperature also causing a decrease in the thickness of the lubricant film between the parts in relative motion. Viscosity index modifiers (Viscosity Index Improvers, VII, or Viscosity Modifiers, VM) influence the viscosity-temperature relationship, slowing down the decrease in the viscosity as the temperature increases, thanks to the conformational variations which their structure undergoes in relation to the thermal conditions.

[0037] Viscosity index modifiers are high-molecular-weight polymers belonging to the following main categories:

- hydrogenated ethylene-propylene copolymers (also called OCP, Olefin Co-Polymers);
- hydrogenated polyisoprenes which can be linear, partially branched or star-shaped;
- polymethacrylates (PMA) of mixtures of short chain alcohols (from C₁ to C₄) and long chain alcohols (from C₁₂ to C₁₈), linear and/or partially branched;
- hydrogenated styrene-isoprene copolymers, which can be linear, partially branched or star-shaped;
- polyisobutenes (PIB).

[0038] At low temperatures, these polymers have a coiled structure which minimizes the interactions with the lubricant base oil; as the temperature increases, the polymer increases the interactions with the base oil, extends its chains and expands, opposing the decrease in viscosity of the lubricant.

[0039] In the production of VMs, the control of the molecular weight and its distribution represents a critical element as these parameters regulate two important characteristics of the polymer such as the thickening efficiency and the mechanical shear stability.

[0040] In the lubricant compositions according to the present invention, the viscosity index modifiers are selected from the modifiers previously described and are preferably hydrogenated ethylene-propylene copolymers. The viscosity index modifiers are present in the lubricant compositions according to the present invention in a quantity varying from 5.0 to 15% by weight, preferably from 7.0 to 12.0% by weight.

Pour Point Depressants

[0041] These additives (Pour Point Depressants, PPD) improve the flow characteristics of the lubricant at low temperature.

[0042] The main pour point improvers consist of polymethacrylates, ethylene-vinylacetate copolymers, polyfumarates.

[0043] The effect of PPDs largely depends on the characteristics of the base oils used and their concentration. The action of these additives is normally more effective with respect to fluid base oils (SN 80, SN 150). Every group of PPDs has an efficacy limit: above a certain percentage, the effect on the pour point ceases and the thickening effect begins to be shown. The typical treat levels vary from 0.1 to 1%.

[0044] In the lubricant compositions according to the present invention, the pour point depressants are selected from the categories previously described and are preferably polyalkylmethacrylates.

[0045] The pour point depressants are present in the lubricant composition according to the present invention in a quantity varying from 0.05 to 0.5% by weight, preferably from 0.1 to 0.3% by weight.

Antioxidants

[0046] Oxidation is the result of the interaction of the lubricant components with oxygen at the operating temperatures of the engine. It is the main cause of degradation of the oil and leads to the formation of acid species which gradually increase in molecular weight, leading to an increase in the viscosity of the lubricant and forming deposits in the engine.

[0047] The oxidative degradation of the lubricant takes place due to a complex series of radical chain reactions, which is contrasted with particular antioxidant or oxidation inhibitor additives. On the one hand, these additives interrupt the chemical reactions responsible for the above processes and on the other, decompose the first degradation products preventing their further evolution towards more harmful species.

[0048] The main antioxidant compounds are: alkylated aromatic amines, sterically hindered phenols, zinc dialkyldithi-

ophosphates, derivatives of dialkyldithiocarbamic acid.

[0049] The amines and hindered phenols act as radical scavengers, transforming the reactive peroxides into inactive species. The zinc dithiophosphates, in addition to acting with these mechanisms, heterolytically decompose the hydroperoxides (ROOH) deactivating them.

[0050] In the lubricant compositions according to the present invention, the antioxidants are selected from the antioxidants previously described and are preferably a mixture of diphenyl-alkylated amines and derivatives of 2,6-di-tert-butyl phenol.

[0051] The antioxidants are present in the lubricant composition according to the present invention in a quantity varying from 0.5 to 3.0% by weight, preferably from 0.7 to 2.0% by weight.

Detergents and dispersants

[0052] Detergents and dispersants form two of the most important categories of engine oil additives and have the function of keeping the surfaces clean. This objective is pursued by attempting to reduce the formation of deposits and also to keep the insoluble products deriving from them in suspension, by preventing their further aggregation and adhesion on the metallic surfaces.

Detergents

[0053] Metallic detergents in particular are used for neutralizing the acid products deriving from combustion (organic acids and sulphur oxides), reducing lacquers and deposits in the pistons and preventing problems in the piston rings under severe temperature conditions. They generally consist of colloidal dispersions, in lubricant base oils, of carbonates of alkaline or alkaline earth metals, stabilized by an adsorbed layer of surfactant molecules. The carbonate nucleus, typically amorphous, represents the alkaline reserve necessary for the neutralization of the acid compounds, whereas the surfactant layer consists of salts of acids with an oleophilic chain sufficiently long (soap) for ensuring the stability of the colloid.

[0054] The main chemical groups of metallic detergents usually adopted are: sulphonates, sulphophenates, salicylates.

[0055] The value of the basic number (BN) determines the neutralizing capacity of the additive, whereas the soap content determines its actual detergent effectiveness. Depending on the neutralizing capacity of the detergent, neutral and overbased detergents can be distinguished.

[0056] In the field of automotive applications detergents based on alkaline earth metals are mainly used, in particular based on calcium or magnesium.

[0057] In the lubricant compositions according to the present invention, the detergents are selected from the detergents previously described and are preferably neutral or overbased calcium or magnesium sulphonates.

[0058] The detergents are present in the lubricant composition according to the present invention in a quantity varying from 1.5 to 5.0% by weight, preferably from 2.0 to 4.0% by weight.

Dispersants

[0059] Dispersants are also fundamental additives for the performances of the end-product, as they control the aggregation state of sludge and, in diesel engines, of soot; in lubricants they generally form over 50% by weight of the total additivation. The most important dispersants are derivatives of succinic anhydrides (succinimides, succinesters, etc.), which are very widely used and whose synthesis is amply described in literature.

[0060] Dispersants also consist of amphiphilic molecules in which the lipophilic portion generally consists of polyolefinic chains (generally polyisobutenes) with a molecular weight varying from 700 to 3,000, whereas the polar group is generally the derivative of a polyamine or a polyol. The bond between these two parts in the final molecule is obtained through different chemical reactions. The most important groups of dispersants are succinimides, succinic esters, alkylphenol amines (Mannich bases), polymeric dispersants.

[0061] Succinimides are probably the most important group that is also produced in greater volumes. The succinic esters used as dispersants for automotive lubricants are products formed by esterifying a succinic derivative of a polyolefin (analogous to those used for succinimides) with mono- or poly-alcohols (for example pentaerythritol), in such a way to produce dispersants with molecular weights generally in the same order of magnitude as those of succinimides.

[0062] Alkylphenol amines (or Mannich bases) consist of polyisobutylene (or polyalkyl-substituted) phenols reacted with polyalkylene amines using formaldehyde, through the Mannich reaction.

[0063] In the lubricant compositions according to the present invention, the dispersants are selected from the dispersants previously described and are preferably succinimides.

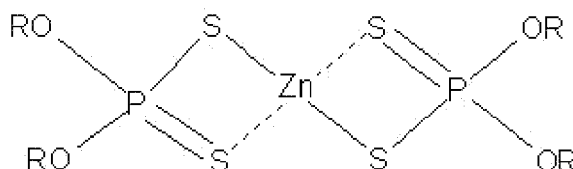
[0064] The dispersants are present in the lubricant composition according to the present invention in a quantity ranging from 4.0 to 12.0% by weight, preferably from 6.0 to 9.0% by weight.

Antiwear additives

[0065] Antiwear additives are additives which are mainly used for reducing wear under extreme lubrication conditions, by reaction with the metallic surfaces on which they form protective tribochemical layers.

[0066] The main group of antiwear additives consists of zinc dialkyl dithiophosphates, whose introduction has been of fundamental importance in the development of the lubricants technology. Antiwear additives based on molybdenum (dialkyl dithiophosphates, dithiocarbamates), organic compounds and metallic detergents are also known.

[0067] The chemical structure of zinc dithiophosphates can be represented by the following formula:



[0068] The alkoxide part (RO) derives from a primary short-chain alcohol (< C₆) or long chain alcohol (C₆-C₈) in primary dithiophosphates or a secondary alcohol (C₃-C₆) in secondary dithiophosphates, rarely from an alkylphenol (aryl dithiophosphates).

[0069] The thermal stability increases according to the following order: secondary, short-chain primary, long-chain primary, aryl, whereas the antiwear effectiveness varies in reverse order. Antiwear additives, in fact, act in this way as, upon decomposing as a result of the temperature, they react with the surfaces and form separation layers. As already mentioned, zinc dithiophosphates also exert a very effective antioxidant action.

[0070] The use of zinc dithiophosphates is currently limited as the phosphorous contained therein, released during the partial combustion of the lubricant, can interact negatively with the catalytic after treatment devices of the exhaust gases.

[0071] In the lubricant compositions according to the present invention, the antiwear additives are selected from the antiwear additives previously described and are preferably zinc dialkyl dithiophosphates. The antiwear additives are present in the lubricant composition according to the present invention in a quantity ranging from 0.5 to 3.0% by weight, preferably from 0.7 to 2.0% by weight.

Friction modifiers

[0072] Friction modifiers or friction reducers (FM) consist of chemical species capable of influencing the friction coefficient under mixed or extreme lubrication conditions.

[0073] Friction modifiers can belong to two main groups: organic and organometallic.

[0074] Organic FMs are generally long, thin molecules, composed of a hydrocarbon chain and a polar terminal group; from a chemical point of view, some of the main families can be identified as:

- carboxylic acids, ethers and esters,
- amides, imides and amines,
- derivatives of phosphoric and phosphonic acids
- organic polymers.

[0075] The heterogeneity of the components also corresponds to different action mechanisms which can be chemically, physically and mechanically stimulated by the running conditions of the engine and by the characteristics of the particular couplings.

[0076] FMs of the organometallic type are mainly molybdenum compounds such as dithiophosphates, dithiocarbamates and amino-complexes which, according to shared interpretations, form MoS₂ structures close to the lubricated surfaces, drastically reducing friction.

[0077] Great attention however is paid to the competitive or synergic action of other additives related to metallic surfaces such as antiwear agents, anticorrosion agents, detergents and dispersants which must be appropriately balanced to obtain optimized performances.

[0078] In the lubricant compositions according to the present invention, the friction modifiers or reducers are selected from the friction modifiers previously described and are preferably dithiocarbamates.

[0079] The friction modifiers or reducers are present in the lubricant composition according to the present invention in a quantity ranging from 0.05 to 0.5% by weight, preferably from 0.1 to 0.3% by weight.

Antifoaming agents

[0080] Antifoaming agents are additives which act by modifying the surface properties of the lubricant at the air-oil interface.

[0081] These are often finely dispersed substances rather than substances dissolved in the liquid: the addition mechanism in the formulation phase is critical.

[0082] It should be pointed out that additives effective towards the formation of external foam compete with those effective towards the formation of internal foam and their action can also be inhibited by other components used in the formulation: the selection of the type(s) of antifoaming agent and the percentages of use is consequently extremely delicate.

[0083] In the lubricant compositions according to the present invention, the antifoaming agents are selected from:

- silicons (for external foam);
- polyacrylates (for internal foam).

[0084] In the lubricant compositions according to the present invention, the antifoaming agents are preferably of the silicon type, in a quantity ranging from 5 to 200 ppm by weight, preferably from 10 to 100 ppm by weight.

[0085] The lubricant compositions according to the present invention preferably consist of lubricating oils in the viscometric grades SAE 5W-XX, 10W-XX and 15W-XX (with XX = 20,30,40,50,60), preferably 10W-40 (defined according to the international classification criteria for engine oils SAE J300, in the edition of November 1, 2007) .

[0086] The following example is provided for a better understanding of the present invention without limiting the scope of the invention in any way.

[0087] The tests described in the example and the engine performances obtained were conducted on a lubricant composition according to the present invention in the viscometric grade SAE 10W-40 having the following composition:

- Base oil of Group II, Eni, called Agip SH5, produced at the Livorno refinery, in a weight percentage equal to 76.9%;
- Package of additives, of Eni technology, called Agip XEU 91310, in a weight percentage of 13.3%;
- Viscosity Modifier: ethylene-propylene copolymer called Agip VE 08, available on the market, in a weight percentage of 9.7%;
- Pour Point Depressant (PPD) of the polyalkylmethacrylic type called Agip VL 300, available on the market, in a weight percentage of 0.1%.

[0088] In particular, with this engine oil, results were achieved, which satisfy the limits imposed by the specifications ACEA A3/B4, API SM/CF, VW 502.00/505.00 and MB 229.3 in various engine tests selected for their performance relevance. Among these results, the most significant, in terms of thermo-oxidative stability, is represented by passing the Volkswagen test T4 (VW PV 1449) which, from common experience, prevents engine oils formulated with Group I base oils, from the possibility of reaching performances stated by the specification VW 502.00/505.00.

[0089] Within the requirements related to fuel saving, the oil, object of the present invention, gave a surprisingly advantageous performance with respect to the Mercedes-Benz test M111 (CEC-L-54-T-96), prescribed by the specification MB 229.3, compared with an analogous product formulated with a mixture of Group I and Group II base oils in a ratio of 1:1.

Example

Evaluation of the lubricant compositions in qualification engine tests

[0090] The performances of the lubricant formulations were evaluated using the following engine tests:

Volkswagen T4 (VW PV 1449)
 ASTM Sequence IIIG
 Peugeot TU5 JP-L4 (CEC-L-88-T-02)
 Volkswagen TDI (CEC-L-78-T-99)
 Mercedes-Benz M111 (CEC-L-54-T-96)
Volkswagen T4 (VW PV 1449)

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[0091] The test evaluates the capability of the lubricant of inhibiting an increase in viscosity, TBN depletion and deposits on the pistons. This test is inserted in the Volkswagen factory and service fill homologation specifications for Otto cycle engines with extended oil drain intervals.

[0092] The test simulates the operation of cars running under high speed, high temperature conditions at full or partial load regimes, together with prolonged idling periods.

[0093] The test is run at a dynamometric bench on a 2.0 litre Volkswagen gasoline engine with 4-cylinders in line.

[0094] The test has a duration of 248 hours divided into two phases:

Phase 1) 0 - 192 hours

[0095]

Step	1	2	3
Time, min	120	72	48
Speed, rpm	4300	4300	Idling
Torque, Nm	Max	75	--
Temp. Oil, °C	133	130	40
Temp. Fluid, °C	100	100	30

Phase 2) 192 - 248 hours

[0096] Constant under the conditions of Step 2 indicated in the table.

[0097] The parts of the engine which are evaluated at the end of the test are the pistons for cleanliness and rings for sticking. The cylinders, cams, rocker arms and seals are inspected visually.

[0098] The pass/fail criteria of the test are defined on the basis of the performance comparison with the reference oil 76409.

[0099] The parameters considered are the absolute viscosity and the viscosity increase of the oil, the TBN level and piston cleanliness after 248 running hours.

ASTM Sequence IIIG

[0100] The test evaluates the thickening of the oil and deposits on the pistons under high-temperature conditions and provides indications on the valve train wear.

[0101] This test is included in the specifications for the API SM and ILSAC GF-4 categories.

[0102] The test simulates running at high speed under relatively severe ambient conditions.

[0103] The test uses a General Motors V-6 Series II of 3800 CC (1996/1997 231 CID) gasoline engine.

[0104] After an initial oil-leveling procedure of 10 minutes, the engine is run for 100 hours in moderate speed regimes (3,600 rpm), load (250 Nm) and lubricant temperature (150°C). Every 20 hours a control of the oil level is carried out and the viscosity increase is measured with respect to the initial charge.

[0105] At the end of the test the following performance parameters are evaluated:

Viscosity increase;

Piston deposits;

Cam wear;

Ring sticking;

Oil consumption.

Peugeot TU5 JP-L4 (CEC-L-88-T-02)

[0106] The test evaluates the oil thickening, high-temperature deposits and ring sticking in a gasoline engine of current technology.

[0107] This test is inserted in the ACEA specifications for the categories "A/B" (Full SAPS) and "C" (Low and Mid SAPS).

[0108] The test simulates high-speed running conditions of the European motorway type, followed by idling regimes.

[0109] The test uses a 1.5 litre Peugeot TU5JP-L4 engine, with 4 cylinders in line, installed on a dynamometric bench.

[0110] The test consists of 6 repeated steps of two-phase 12-hour cycles for a total duration of 72 hours.

[0111] Phase 1 (11 and 50 minutes) is run at a maximum power at 5,600 rpm, and 150°C, for both the oil and cooling

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fluid. Phase 2 (10 minutes) is under idling conditions.

[0112] At the end of the test, the pistons are inspected with respect to lacquers, carbon deposits and ring sticking.

[0113] The kinematic viscosity of the lubricant oil is measured every 12 hours and compared with the value related to the initial charge.

Volkswagen TDI (CEC-L-78-T-99)

[0114] The test evaluates the piston cleanliness and sticking tendency of the rings in a direct injection Volkswagen diesel engine.

[0115] This test is inserted in the ACEA specifications for the categories "A/B" (Full SAPS) and "C" (Low and Mid SAPS), and also in the Volkswagen specifications for extended oil drain intervals (e.g. VW 502.00/505.00).

[0116] The test simulates typically European high-speed operation regimes, followed by idling conditions.

[0117] The dynamometric bench installation uses a 1.9 litre direct injection Volkswagen diesel engine (VW TDI), with 4 cylinders in line, equipped with a turbocharger.

[0118] The test lasts 54 hours, with an alternating 2-phase cycle of idling (30 minutes and 40°C of the sump oil) and full load at 4,150 rpm (150 minutes and 145°C of the sump oil). Furthermore, no top-up of lubricant is allowed during the test.

[0119] At the end of the test, the pistons are evaluated with respect to the lacquer and carbon deposits; the rings with respect to sticking.

[0120] Determinations of the kinematic viscosity at 40°C and 100°C and TBN on new and used oil, are also carried out.

[0121] The pass/fail criteria are defined for comparison with the performances of the reference oil RL 206.

Mercedes-Benz M111 (CEC-L-54-T-96)

[0122] The test evaluates the effect of the engine oil on the fuel economy in a light-duty gasoline engine for passenger cars.

[0123] The test is inserted in the ACEA specifications for the categories "A/B" (Full SAPS) and "C" (Low and Mid SAPS), and also in the Mercedes specifications for extended oil drain intervals.

[0124] The test is based on the European procedure (NEDC) for the determination of the regulated exhaust emissions.

[0125] The test is run at a dynamometric bench on a 2.0 litre Mercedes-Benz M111 E20 4-cylinder gasoline engine with a port fuel injection system.

[0126] The test has the duration of 24 hours and includes a cycle on the reference oil before running three repeated cycles on the oil to be tested.

[0127] Aging sequences under stationary conditions are also included.

[0128] The test cycle consists of 2 parts and 8 steps in which the speed, load, temperature of the oil and cooling fluid are varied for a unitary period of 2 hours, 24 minutes and 10 seconds, during which the measurement of the fuel consumption is carried out.

[0129] The result of the test is expressed in terms of percentage variation in the fuel consumption of the candidate with respect to the reference oil.

Engine results achieved

[0130] The results of the tests selected for demonstrating the quality of the illustrative lubricant formulation of the invention are indicated hereunder.

[0131] The analysis and evaluation methods used for determining the performance parameters are those defined by the official standard engine test procedures.

Test Volkswagen T4 (PV 1449)

Oil with Group II base oil 10W-40

[0132]

Oil SAE Grade	Oil with Group VW II base oil 10W-40	502.00 LIMITS
Ring sticking, ASF	0	None
Piston varnish, merit	3.45	1 min

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(continued)

Oil SAE Grade	Oil with Group VW II base oil 10W-40	502.00 LIMITS
Viscosity increase at 40°C, %	79.7	126.99 max
Viscosity at 40°C at the end of test, cSt	163.7	197.67 max
Base number, mgKOH/g	8.3	5.31 min

Synthetic oil SAE 5W-40

[0133]

Oil SAE Grade	Synthetic oil 5W-40	VW 502.00 LIMITS
Ring sticking, ASF	0	None
Piston varnish, merit	2.78	1.0 min
Viscosity increase at 40°C, %	88.7	139.19 max
Viscosity at 40°C at the end of test, cSt	175.9	208.94 max
Base number, mgKOH/g	7.8	5.34 min

Test ASTM Sequence IIIG

Oil with Group II base oil SAE 10W-40

[0134]

Oil SAE Grade	Oil with Group II base oil 10W-40	API SM LIMITS
Viscosity increase at 40°C, %	87.6	150 max
Average Weighted Piston Deposits, merit	6.12	3.5 min
Average Cam plus Lifter Wear, µm	51.6	60 max
Hot Stuck Rings	0	None

Test Peugeot TU5JP-L4 (CEC-L-88-T-02)

Oil with Group II base oil SAE 10W-40

[0135]

Oil SAE Grade	Oil with Group II base oil 10W-40	A3/B4 LIMITS
Absolute viscosity increase (max-min) at 40°C, cSt	36.63	53.2 max

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(continued)

Oil SAE Grade	Oil with Group II base oil 10W-40	A3/B4 LIMITS
Piston varnish, merit	9.2	7.0 min
Ring sticking (each part), merit	10	9.0 min

Test Volkswagen Golf TDI (CEC L-78-T-99)

Oil with Group II base oil SAE 10W-40

[0136]

Oil SAE Grade	Oil with Group II base oil 10W-40	A3/B4 LIMITS
Ring sticking (Rings 1 & 2): Average of all 8 rings, ASF	0	1.2 max
Max. for any first ring, ASF	0	2.5 max
Max. for any second ring, ASF	0	0.0 max
Piston Cleanliness, merit	62.3	62 min

Test Mercedes-Benz M111 (CEC-L-54-T-96)

Oil with Group II base oil SAE 10W-40

[0137]

Oil SAE Grade	Oil with Group II base oil 10W-40	MB 229.3 LIMITS
"Fuel economy" improvement versus Reference Oil RL 191 (15W-40), %	1.17	1.0 min

Oil with mixture of Group I/Group II base oils SAE 10W-40

[0138]

Oil SAE Grade	Mixture of Group I/Group II base oils 10W-40	MB 229.3 LIMITS
"Fuel economy" improvement versus Reference Oil RL 191 (15W-40), %	0.77	1.0 min

Claims

1. Lubricant compositions comprising:

- (a) from 50 to 90% by weight of base oils of Group II (API) having a volatility comprised between 7.0 and 10.0% by weight and a viscosity index comprised between 110 and 119;
- (b) from 10 to 50% by weight of additives selected from antioxidants, anti-wear additives, detergents, dispersants, viscosity index modifiers, pour point depressants, antifoaming agents, friction modifier or friction reducer additives.

2. Lubricant compositions according to claim 1, **characterised in that** they comprise:

(a) from 60 to 80% by weight of base oils of Group II (API) having a volatility comprised between 7.0 and 10.0% by weight and a viscosity index comprised between 110 and 119;

(b) from 20 to 40% by weight of additives selected from:

antioxidants, in an amount ranging from 0.5 to 3.0% by weight, preferably from 0.7 to 2.0% by weight;
 anti-wear additives, in an amount ranging from 0.5 to 3.0% by weight, preferably from 0.7 to 2.0% by weight;
 detergents, in an amount ranging from 1.5 to 5.0% by weight, preferably from 2.0 to 4.0% by weight;
 dispersants, in an amount ranging from 4.0 to 12.0% by weight, preferably from 6.0 to 9.0% by weight;
 pour point depressants, in an amount ranging from 0.05 to 0.5% by weight, preferably from 0.1 to 0.3% by weight;
 antifoaming agents, in an amount ranging from 5 to 200 ppm by weight, preferably from 10 to 100 ppm by weight;
 friction modifier or friction reducer additives, in an amount ranging from 0.05 to 0.5% by weight, preferably from 0.1 to 0.3% by weight;
 viscosity index modifiers, in an amount ranging from 5.0 to 15% by weight, preferably from 7.0 to 12.0% by weight.

3. Lubricant compositions according to any one of the preceding claims, **characterised in that** the base oils of Group II (API) have a volatility comprised between 7.0 and 9.0 % by weight.

4. Lubricant compositions according to any one of the preceding claims, **characterised in that** the base oils of Group II (API) have a viscosity index comprised between 113 and 119.

5. Lubricant compositions according to any one of the preceding claims, **characterised in that** the antioxidant is a mixture of diphenyl-alkylated amines and derivatives of 2,6-di-tert-butyl phenol.

6. Lubricant compositions according to any one of the preceding claims, **characterised in that** the anti-wear additive is selected from zinc dialkyldithiophosphates.

7. Lubricant compositions according to any one of the preceding claims, **characterised in that** the detergent is selected from neutral or overbased calcium or magnesium sulphonates.

8. Lubricant compositions according to any one of the preceding claims, **characterised in that** the dispersant is selected from succinimides.

9. Lubricant compositions according to any one of the preceding claims, **characterised in that** the pour point depressant is selected from polyalkylmethacrilates.

10. Lubricant compositions according to any one of the preceding claims, **characterised in that** the antifoaming additive is selected from additives of the silicon type.

11. Lubricant compositions according to any one of the preceding claims, **characterised in that** the friction modifier or reducer is selected from dithiocarbamates.

12. Lubricant compositions according to any one of the preceding claims, **characterised in that** the viscosity index modifiers are hydrogenated ethylene-propylene copolymers.

13. Lubricant compositions according to any one of the preceding claims, **characterised in that** they consist of lubricant oils of SAE 5W-XX, 10W-XX and 15W-XX viscometric grades (with XX = 20,30,40,50,60), preferably 10W-40 (as defined according to SAE J300 international classification criteria for engine oils, November 1st, 2007 Edition).

14. Use of the lubricant compositions according to any one of claims 1-13 as an automotive engine oil.



EUROPEAN SEARCH REPORT

Application Number
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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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