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(54) INDUSTRIAL GEAR OILS IMPARTING REDUCED GEARBOX OPERATING TEMPERATURES

INDUSTRIELLE GETRIEBEÖLE FÜR NIEDRIGERE GETRIEBEBETRIEBSTEMPERATUREN

HUILES INDUSTRIELLES POUR ENGRENAGES PERMETTANT DE RÉDUIRE LES TEMPÉRATURES DE FONCTIONNEMENT D'UN RÉDUCTEUR

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Description

Field of the Invention

[0001] The invention relates to the use of a fatty phosphite for reducing the operating temperature of an industrial gearbox.

Background of the Invention

[0002] Industrial gearboxes see extreme operating conditions that can lead to damage, for example, wear to the internal components of the gearbox. This damage reduces the life of the industrial gearbox and can lead to costly and prolonged maintenance, repair costs, unscheduled downtime for the equipment that contains the industrial gearbox, and similar problems.

[0003] There is an on-going need for improved industrial gearbox lubricants that can provide better performance in and protection of industrial gearboxes, thus extending the service life of the industrial gearboxes and the equipment that contains them.

[0004] One means of protecting an industrial gearbox and extending the life of the fluid lubricating them is to reduce the temperature at which it operates. It is generally known that extended exposure to the high temperatures that industrial gearboxes commonly operate under increases the wear and tear on the parts of the gearboxes, eventually leading to part failure. This negative impact of high operating temperature is the result of multiple forces, including but not limited to the fact that the high temperatures can accelerate the break-down of the protective additives and increase the oxidation of the base fluid present in the industrial gearbox lubricant, thus leaving the parts of the gearbox less protected over time. Reducing the operating temperature of an industrial gearbox will result in improved performance over time.

[0005] One means of reducing the operating temperature of an industrial gearbox is by use of an external cooler or the addition of radiating fins. However, such approaches have limitations and can involve costly and time consuming modifications to existing equipment. There is a need for an approach that reduces the operating temperature of an industrial gearbox in existing equipment without the need for such modifications.

[0006] An alternative to reducing gearbox operating temperature would be to operate the equipment at a lower level (lower load, lower power, lower speed, etc.). However, this approach generally leads to a reduction in production and/or efficiency and so is not an attractive option to equipment operators trying to maintain productivity. Instead, there is a need for industrial gearbox lubricants that can reduce the operating temperature of an industrial gearbox without sacrificing operation levels (equipment load, power, speed, etc.). US 2006/223720 A1 discloses a method for reducing operating temperatures in a driveline component.

[0007] It has now been found that the use of the present invention can provide a reduction in industrial gearbox operating temperature with no other changes to equipment operating conditions.

Summary of the Invention

[0008] The invention provides the use of a fatty phosphite for reducing the operating temperature of an industrial gearbox, said use comprising the steps of: (I) adding to an industrial gear oil lubricant comprising (a) an oil of lubricating viscosity, and (b) an industrial gear lubricant additive package, (c) a fatty phosphite such that the lubricant contains at least 1.0 percent by weight fatty phosphite, and (II) operating the industrial gearbox while supplying the industrial gear oil lubricant to the industrial gearbox, wherein (b) the industrial gear lubricant additive package comprises one or more antiwear additives and/or extreme pressure agents, one or more rust and/ or corrosion inhibitors, one or more foam inhibitors, one or more demulsifiers, or any combination thereof.

Detailed Description of the Invention

[0009] Various features and embodiments of the invention will be described below by way of non-limiting illustration.

[0010] The industrial gear compositions include: (a) an oil of lubricating viscosity; (b) an industrial gear lubricant additive package; and (c) a fatty phosphite present at no less than 1.0 percent by weight of the overall composition. In some embodiments the industrial gear lubricant additive package may include a demulsifier, a dispersant, and a metal deactivator. The 1.0 percent by weight minimum of the fatty phosphite is included as it is believed that, in at least some embodiments, at least this amount of fatty phosphite is necessary to see the described benefits in the industrial gear oil compositions, namely the reduced gearbox operating temperature. The extent to which the benefits of the invention are seen are expected to vary and/or be dependent somewhat on the base fluid used.

The Oil of Lubricating Viscosity

[0011] The oil of lubricating viscosity can be present in a major amount, for a lubricant composition, or in a concentrate forming amount, for a concentrate and/or additive composition.

[0012] Suitable oils include natural and synthetic lubricating oils and mixtures thereof. In a fully formulated lubricant, the oil of lubricating viscosity is generally present in a major amount (i.e. an amount greater than 50 percent by weight). Typically, the oil of lubricating viscosity is present in an amount of 75 to 98 percent by weight, and often greater than 80 percent by weight of the overall composition.

[0013] The oil of lubricating viscosity may include natural and synthetic oils, oil derived from hydrocracking, hydrogenation, and hydrofinishing, unrefined, refined and re-refined oils or mixtures thereof. Unrefined oils are those obtained directly from a natural or synthetic source generally without (or with little) further purification treatment. Refined oils are similar to the unrefined oils except they have been further treated in one or more purification steps to improve one or more properties. Purification techniques are known in the art and include solvent extraction, secondary distillation, acid or base extraction, filtration, percolation and similar processes. Re-refined oils are also known as reclaimed or reprocessed oils, and are obtained by processes similar to those used to obtain refined oils. Re-refined oils are often are processed by techniques directed to removal of spent additives and oil breakdown products.

[0014] Natural oils useful as the oil of lubricating viscosity include animal oils and vegetable oils (e.g., castor oil, lard oil), mineral lubricating oils such as liquid petroleum oils and solvent-treated or acid-treated mineral lubricating oils of the paraffinic, naphthenic or mixed paraffinic naphthenic types and oils derived from coal or shale or mixtures thereof.

[0015] Synthetic oils of lubricating viscosity include hydrocarbon oils such as polymerized and interpolymerised olefins (e.g., polybutylenes, polypropylenes, propyleneisobutylene copolymers); poly(1-hexenes), poly(1-octenes), poly(1-decenes), and mixtures thereof; alkyl-benzenes (e.g., dodecylbenzenes, tetradecylbenzenes, dinonylbenzenes, di-(2-ethylhexyl)-benzenes); polyphenyls (e.g., biphenyls, terphenyls, alkylated polyphenyls); alkylated biphenyl ethers and alkylated biphenyl sulfides and the derivatives, analogs and homologs thereof or mixtures thereof. In some embodiments the oil of lubricating viscosity used in the invention is a synthetic oil that includes polymerized polyisobutylene, and in some embodiments the oil of lubricating viscosity used in the invention is a synthetic oil that includes polymerized polyisobutylene and a polyalphaolefin.

[0016] Another synthetic oil of lubricating viscosity includes polyol esters other than the hydrocarbyl-capped polyoxyalkylene polyol as disclosed herein, dicarboxylic esters, liquid esters of phosphorus-containing acids (e.g., tricresyl phosphate, trioctyl phosphate, and the diethyl ester of decane phosphonic acid), or polymeric tetrahydrofurans. Synthetic conventional oil of lubricating viscosity also includes those produced by Fischer-Tropsch reactions and typically may be hydroisomerised Fischer-Tropsch hydrocarbons or waxes. In one embodiment, the oil of lubricating viscosity may be prepared by a Fischer-Tropsch gas-to-liquid synthetic procedure as well as other gas-to-liquid oils.

[0017] Oils of lubricating viscosity may further be defined as specified in the American Petroleum Institute (API) Base Oil Interchangeability Guidelines. The five base oil groups are as follows: Group I (sulfur content >0.03 percent by weight, and/or <90 percent by weight saturates, viscosity index 80-120); Group II (sulfur content $\leq$0.03 percent by weight and $\geq$90 percent by weight saturates, viscosity index 80-120); Group III (sulfur content $\leq$0.03 percent by weight and $\geq$90 percent by weight saturates, viscosity index $\geq$120); Group IV (all polyalphaolefins, or PAO, such as PAO-2, PAO-4, PAO-5, PAO-6, PAO-7 or PAO-8); and Group V (which encompasses "all others"). The oil of lubricating viscosity includes API Group I, Group II, Group III, Group IV, Group V oil or mixtures thereof. In one embodiment, the oil of lubricating viscosity is an API Group I, Group II, Group III, Group IV oil or mixtures thereof. Alternatively, the oil of lubricating viscosity is often an API Group II, Group III or Group IV oil or mixtures thereof.

[0018] In some embodiments, the lubricating oil component includes a Group II or Group III base oil, or a combination thereof. The oil can also be derived from the hydroisomerization of wax, such as slack wax or a Fischer-Tropsch synthesized wax. Such "Gas-to-Liquid" oils are typically characterized as Group III.

[0019] The compositions may include some amount of Group I base oils, and even Group IV and Group V base oils. However, in some embodiments, the lubricating oil component contains no more than 20, 10, 5, or even 1 percent by weight Group I base oil. These limits may also apply to Group IV or Group V base oils. In other embodiments, the lubricating oil present in the compositions is at least 60, 70, 80, 90, or even 98 percent by weight Group II and/or Group III base oil. In some embodiments, the lubricating oil present in the compositions is essentially only Group II and/or Group III base oil, where small amounts of other types of base oils may be present but not in amounts that significantly impact the properties or performance of the overall composition.

[0020] In some embodiments, the compositions include some amount of Group I and/or Group II base oils. In other embodiments, the compositions are lubricating compositions where the oil of lubricating viscosity is primarily Group I and/or Group II base oils, or even essentially Group I and/or Group II base oils, or even exclusively Group I and/or Group II base oils.

[0021] In some embodiments, the invention provides a Group II composition, that is the oil of lubricating viscosity includes Group II oil, and can even be primarily if not exclusively Group II oil, while still providing synthetic oil composition

performance. This is one of the benefits of the present invention.

[0022] The various described oils of lubricating viscosity may be used alone or in combinations. The oil of lubricating viscosity may be used in the described industrial gear lubricants in the range of about 80 percent by weight to about 98 percent by weight, or from 80, 85, 90, 95, 97 or even 97.5 or 98 percent by weight oil or up to 90, 95, 97, 97.5, or even 98 percent by weight oil. The oil of lubricating viscosity may be used as diluent in the described industrial gear additive concentrates in the range of about 1 percent by weight to about 49 percent by weight, or from 1, 5, even 10 percent by weight oil up to 10, 20, 30, 40, or even 45 or 49 percent by weight oil.

The Industrial Gear Lubricant Additive Package

[0023] The compositions include an industrial gear additive package. In other words, the compositions of the invention are designed to be industrial gear lubricants, or additive packages for making the same. The present invention does not relate to automotive gear lubricants or other lubricating compositions.

[0024] In some embodiments, the industrial gear lubricant additive package includes a demulsifier, a dispersant, and a metal deactivator. Any combination of conventional additive packages designed for industrial gear application may be used. The invention inherently assumes such additive packages are essentially free of the fatty phosphites of the present invention, or at least do not contain the type of fatty phosphites specified by the invention in the amounts specified.

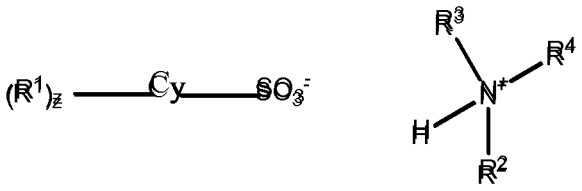
[0025] The additives which may be present in the industrial gear additive package include a foam inhibitor, a demulsifier, a pour point depressant, an antioxidant, a dispersant, a metal deactivator (such as a copper deactivator), an antiwear agent, an extreme pressure agent, a viscosity modifier, or some mixture thereof. The additives may each be present in the range from 50, 75, 100 or even 150 ppm up to 5, 4, 3, 2 or even 1.5 percent by weight, or from 75 ppm to 0.5 percent by weight, from 100 ppm to 0.4 percent by weight, or from 150 ppm to 0.3 percent by weight, where the percent by weight values are with regards to the overall lubricating oil composition. However, it is noted that some additives, including viscosity modifying polymers, which may alternatively be considered as part of the base fluid, may be present in higher amounts including up to 30, 40, or even 50% by weight when considered separate from the base fluid. The additives may be used alone or as mixtures thereof.

[0026] Antifoams, also known as foam inhibitors, are known in the art and include but are not limited to organic silicones and non-silicon foam inhibitors. Examples of organic silicones include dimethyl silicone and polysiloxanes. Examples of non-silicon foam inhibitors include but are not limited to polyethers, polyacrylates and mixtures thereof as well as copolymers of ethyl acrylate, 2-ethylhexylacrylate, and optionally vinyl acetate. In some embodiments, the antifoam is a polyacrylate. Antifoams may be present in the composition from 0.001 to 0.012 or 0.004 pbw or even 0.001 to 0.003 pbw.

[0027] Demulsifiers are known in the art and include but are not limited to derivatives of propylene oxide, ethylene oxide, polyoxyalkylene alcohols, alkyl amines, amino alcohols, diamines or polyamines reacted sequentially with ethylene oxide or substituted ethylene oxides or mixtures thereof. Examples of demulsifiers include polyethylene glycols, polyethylene oxides, polypropylene oxides, (ethylene oxidepropylene oxide) polymers and mixtures thereof. In some embodiments, the demulsifiers are polyethers. Demulsifiers may be present in the composition from 0.002 to 0. 2 pbw.

[0028] Pour point depressants are known in the art and include but are not limited to esters of maleic anhydride-styrene copolymers, polymethacrylates; polyacrylates; polyacrylamides; condensation products of haloparaffin waxes and aromatic compounds; vinyl carboxylate polymers; and terpolymers of dialkyl fumarates, vinyl esters of fatty acids, ethylene-vinyl acetate copolymers, alkyl phenol formaldehyde condensation resins, alkyl vinyl ethers and mixtures thereof.

[0029] The compositions may also include a rust inhibitor, other than some of the additives described above. Suitable rust inhibitors include hydrocarbyl amine salts of dialkyldithiophosphoric acid, hydrocarbyl amine salts of hydrocarbyl arenesulphonic acid, fatty carboxylic acids or esters thereof, an ester of a nitrogen-containing carboxylic acid, an ammonium sulfonate, an imidazoline, mono-thio phosphate salts or esters, or any combination thereof; or mixtures thereof. Examples of hydrocarbyl amine salts of dialkyldithiophosphoric acid of the invention include but are not limited to those described above, as well as the reaction product(s) of diheptyl or dioctyl or dinonyl dithiophosphoric acids with ethylenediamine, morpholine or Primene™ 81R or mixtures thereof. Suitable hydrocarbyl amine salts of hydrocarbyl arenesulphonic acids used in the rust inhibitor package are represented by the formula:



(V)

wherein Cy is a benzene or naphthalene ring. R^1 is a hydrocarbyl group with about 4 to about 30, preferably about 6 to

about 25, more preferably about 8 to about 20 carbon atoms. z is independently 1, 2, 3, or 4 and most preferably z is 1 or 2. R^2, R^3 and R^4 are the same as described above. Examples of hydrocarbyl amine salts of hydrocarbyl arenesulphonic acid include but are not limited to the ethylenediamine salt of dinonylnaphthalene sulfonic acid. Examples of suitable fatty carboxylic acids or esters thereof include glycerol monooleate and oleic acid. An example of a suitable ester of a nitrogen-containing carboxylic acid includes oleyl sarcosine. The rust inhibitors may be present in the range from 0.02 to 0.2, from 0.03 to 0.15, from 0.04 to 0.12, or from 0.05 to 0.1 percent by weight of the lubricating oil composition. The rust inhibitors may be used alone or in mixtures thereof.

[0030] The compositions of the invention may also include a metal deactivator. Metal deactivators are used to neutralise the catalytic effect of metal for promoting oxidation in lubricating oil. Suitable metal deactivators include but are not limited to triazoles, tolyltriazoles, a thiadiazole, or combinations thereof, as well as derivatives thereof. Examples include derivatives of benzotriazoles other than those described above, benzimidazole, 2-alkyldithiobenzimidazoles, 2-alkyldithiobenzothiazoles, 2-(N,N'-dialkyldithio-carbamoyl)benzothiazoles, 2,5-bis(alkyl-dithio)-1,3,4-thiadiazoles, 2,5-bis(N,N'-dialkyldithiocarbamoyl)-1,3,4-thiadiazoles, 2-alkyldithio-5-mercapto thiadiazoles or mixtures thereof. These additives may be used from 0.01 to 0.25 percent by weight in the overall composition. In some embodiments, the metal deactivator is a hydrocarbyl substituted benzotriazole compound. The benzotriazole compounds with hydrocarbyl substitutions include at least one of the following ring positions 1- or 2- or 4- or 5- or 6- or 7- benzotriazoles. The hydrocarbyl groups contain about 1 to about 30, preferably about 1 to about 15, more preferably about 1 to about 7 carbon atoms, and most preferably the metal deactivator is 5-methylbenzotriazole used alone or mixtures thereof. The metal deactivators may be present in the range from 0.001 to 0.5, from 0.01 to 0.04 or from 0.015 to 0.03 pbw of the lubricating oil composition. Metal deactivators may also be present in the composition from 0.002 or 0.004 to 0.02 pbw. The metal deactivator may be used alone or mixtures thereof.

[0031] Antioxidants may also be present including (i) an alkylated diphenylamine, and (ii) a substituted hydrocarbyl mono-sulfide. In some embodiments, the alkylated diphenylamines of the invention are bis-nonylated diphenylamine and bis-octylated diphenylamine. In some embodiments, the substituted hydrocarbyl monosulfides include n-dodecyl-2-hydroxyethyl sulfide, 1-(tert-dodecylthio)-2-propanol, or combinations thereof. In some embodiments the substituted hydrocarbyl monosulfide is 1-(tertdodecylthio)-2-propanol. The antioxidant package may also include sterically hindered phenols. Examples of suitable hydrocarbyl groups for the sterically hindered phenols include but are not limited to 2-ethylhexyl or n-butyl ester, dodecyl or mixtures thereof. Examples of methylene-bridged sterically hindered phenols include but are not limited to 4,4-methylene-bis(6-tert-butyl o-cresol), 4,4-methylene-bis(2-tert-amyl-o-cresol), 2,2'-methylene-bis(4-methyl-6-tert-butylphenol), 4,4'-methylene-bis(2,6-di-tertbutylphenol) or mixtures thereof.

[0032] In some embodiments, the industrial gear lubricant additive package includes a nitrogen-containing dispersant, for example a hydrocarbyl substituted nitrogen containing additive. Suitable hydrocarbyl substituted nitrogen containing additives include ashless dispersants and polymeric dispersants. Ashless dispersants are so-named because, as supplied, they do not contain metal and thus do not normally contribute to sulfated ash when added to a lubricant. However, they may, of course, interact with ambient metals once they are added to a lubricant which includes metal-containing species. Ashless dispersants are characterized by a polar group attached to a relatively high molecular weight hydrocarbon chain. Examples of such materials include succinimide dispersants, Mannich dispersants, and borated derivatives thereof.

[0033] In some embodiments, the industrial gear lubricant additive package includes a sulfur-containing compound. Suitable sulfur-containing compounds include sulfurized olefins and polysulfides. The sulfurized olefin or polysulfides may be derived from isobutylene, butylene, propylene, ethylene, or some combination thereof. In some examples, the sulfur-containing compound is a sulfurized olefin derived from any of the natural oils or synthetic oils described above, or even some combination thereof. For example, the sulfurized olefin may be derived from vegetable oil.

[0034] In some embodiments, the industrial gear additive packages include one or more phosphorous amine salts, but in amounts such that the additive package, or in other embodiments the resulting industrial gear lubricant compositions, contains no more than 1.0 percent by weight of such materials, or even no more than 0.75 or 0.6 percent by weight. In other embodiments, the industrial gear additive packages, or the resulting industrial gear lubricant compositions, are essentially free of or even completely free of phosphorous amine salts.

[0035] In some embodiments, component (b), the industrial gear lubricant additive package, comprises one or more antiwear additives and/or extreme pressure agents, one or more rust and/or corrosion inhibitors, one or more foam inhibitors, one or more demulsifiers, or any combination thereof.

[0036] In some embodiments, the industrial gear additive packages, or the resulting industrial gear lubricant compositions, are essentially free of or even completely free of phosphorous amine salts, dispersants, or both.

[0037] In some embodiments, the industrial gear additive packages, or the resulting industrial gear lubricant compositions, include a demulsifier, a corrosion inhibitor, a friction modifier, or combination of two or more thereof. In some embodiments, the corrosion inhibitor includes a tolyltriazole. In still other embodiments, the industrial gear additive packages, or the resulting industrial gear lubricant compositions, include one or more sulfurized olefins or polysulfides; one or more phosphorus amine salts; one or more thiophosphate esters, one or more thiadiazoles, tolyltriazoles, poly-

ethers, and/or alkenyl amines; one or more ester copolymers; one or more carboxylic esters; one or more succinimide dispersants, or any combination thereof.

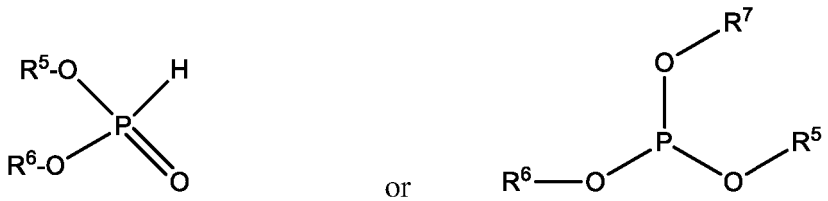
[0038] The industrial gear additive package may be present in the overall industrial gear lubricant from 1 to 5 percent by weight, or in other embodiments from 1, 1.5, or even 2 percent by weight up to 2, 3, 4, 5, 7 or even 10 percent by weight. Amounts of the industrial gear additive package that may be present in the industrial gear concentrate compositions of the invention are the corresponding amounts to the weight percent above; where the values are considered without the oil present (i.e., they may be treated as pbw values along with the actual amount of oil present).

The fatty phosphite

[0039] The compositions of include a fatty phosphite present at no less than 1.0 percent by weight of the overall lubricant composition.

[0040] Suitable phosphites include those having at least one hydrocarbyl group with 4 or more, or 8 or more, or 12 or more, carbon atoms. Typical ranges for the number of carbon atoms on the hydrocarbyl group include 8 to 30, or 10 to 24, or 12 to 22, or 14 to 20, or 16 to 18. The phosphite may be a mono-hydrocarbyl substituted phosphite, a dihydrocarbyl substituted phosphite, or a tri-hydrocarbyl substituted phosphite. In one embodiment, the phosphite is sulphur-free, i.e., the phosphite is not a thiophosphite.

[0041] The phosphite having at least one hydrocarbyl group with 4 or more carbon atoms may be represented by the formulae:



wherein at least one of R^5, R^6 and R^7 may be a hydrocarbyl group containing at least 4 carbon atoms and the other may be hydrogen or a hydrocarbyl group. In one embodiment, R^5, R^6 and R^7 are all hydrocarbyl groups. The hydrocarbyl groups may be alkyl, cycloalkyl, acyclic or mixtures thereof. In the formula with all three groups R^5, R^6 and R^7, the compound may be a tri-hydrocarbyl substituted phosphite i.e., R^5, R^6 and R^7 are all hydrocarbyl groups.

[0042] Alkyl groups may be linear or branched, typically linear, and saturated. Examples of alkyl groups for R^5, R^6 and R^7 include octyl, 2-ethylhexyl, nonyl, decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, nonadecyl, eicosyl or mixtures thereof.

[0043] In some embodiments, the fatty phosphite component and/or the composition overall, is essentially free of, or even completely free of phosphoric acid ester and/or amine salts thereof.

[0044] In some embodiments, the fatty phosphite comprises an alkyl phosphite, for example, dimethyl hydrogen phosphite.

[0045] The fatty phosphite may be present in the overall industrial gear lubricant from 1.0 to 10.0 percent by weight, or in other embodiments from 1, 1.5, or even 2 percent by weight up to 1.5, 1.9, 2, 3, 4, 5, 7 or even 10 percent by weight. Amounts of the industrial gear additive package that may be present in the industrial gear concentrate compositions are the corresponding amounts to the weight percent above; where the values are considered without the oil present (i.e., they may be treated as pbw values along with the actual amount of oil present).

[0046] In some embodiments, the ratio of the industrial gear additive package component (component (b)) relative to the fatty phosphite component (component (a)), on an oil free weight basis, is from 1:0.5 to 1:1.5. In still further embodiments, this ratio of components (b):(c) is 1:0.5 to 1:1.5, or 1:0.6 to 1:1.2, or 1:0.7 to 1:1.1, or 1:0.8 to 1:1.0.

Industrial Application

[0047] In the industrial gear lubricants: component (a), the oil of lubricating viscosity, may be present from 80, 85, 90, 95, 97 or even 97.5 or 98 percent by weight oil up to 90, 95, 97, 97.5, or even 98 percent by weight; component (b), the industrial gear lubricant additive package, may be present from 1, 1.5, or even 2 percent by weight up to 2, 3, 4, 5, 7 or even 10 percent by weight; and component (c), the fatty phosphite, may be present from 1, 1.5, or even 2 percent by weight up to 1.5, 1.9, 2, 3, 4, 5, 7 or even 10 percent by weight.

[0048] In the industrial gear additive concentrates: component (a), the oil of lubricating viscosity, may be present from 1, 5, even 10 percent by weight oil up to 10, 20, 30, 40, or even 45 or 49 percent by weight; component (b), the industrial gear lubricant additive package, may be present from 20, 25, 25.5, 27.5, 30, 35, 45 or even 45 percent by weight up to

45, 47.5, or even 49.5 percent by weight; and component (c), the fatty phosphite, may be present from 25.5, 27.5, 30, 35, 45 or even 45 percent by weight up to 45, 47.5, or even 49.5 percent by weight

[0049] In some embodiments, the ratio of the industrial gear additive package component (component (b)) relative to the fatty phosphite component (component (a)), on an oil free weight basis, is from 1:0.5 to 1:1.5. In still further embodiments, the ratio of components (b):(c) is from 4:1 to 1:5, or from 2:1 to 1:5, or from 1:1 to 1:5, or from 1:0.5 to 1:1.5, or 1:0.6 to 1:1.2, or 1:0.7 to 1:1.1, or 1:0.8 to 1:1.0. These ratios may apply to the industrial gear lubricants and/or to the industrial gear additive concentrates.

[0050] In some embodiments at least a portion, if not all of the fatty phosphite is added to the industrial gear oil lubricant before the lubricant is supplied to the industrial gearbox. In other embodiments at least a portion, if not all of the fatty phosphite is added to the industrial gear oil lubricant after the lubricant is supplied to the industrial gearbox.

[0051] In some embodiments, the compositions are essentially free of, or even completely free of: copolymers comprising units derived from two or more methacrylic acid esters. More specifically, in some embodiments the compositions are essentially free of, or even completely free of: copolymers comprising units derived from (a) methacrylic acid esters containing from 9 to 25 carbon atoms in the ester group and (b) methacrylic acid esters containing from 7 to 12 carbon atoms in the ester group, said ester groups having 2-(C_{1-4} alkyl)-substituents, and optionally (c) at least one monomer selected from the group consisting of methacrylic acid esters containing from 2 to 8 carbon atoms in the ester group atoms and which are different from methacrylic acid esters (a) and (b), vinyl aromatic compounds, and nitrogen-containing vinyl monomers with the proviso that no more than 60% by weight of the esters contain not more than 11 carbon atoms in the ester group.

[0052] In some embodiments, the compositions are essentially free of, or even completely free of: a nitrogen-containing ester derived from a carboxy-containing interpolymer having a reduced specific viscosity (RSV) of from about 0.05 to about 2, said interpolymer being derived from at least two monomers. More specifically, in some embodiments, the compositions are essentially free of, or even completely free of: a nitrogen-containing ester derived from a carboxy-containing interpolymer having a reduced specific viscosity (RSV) of from about 0.05 to about 2, said interpolymer being derived from at least two monomers, (i) one of said monomers being at least one of an aliphatic olefin containing from 2 to about 30 carbon atoms and a vinyl aromatic monomer and (ii) the other of said monomers being at least one alpha, beta-unsaturated acylating agent, said ester being characterized by the presence within its polymeric structure of each of the following groups which are derived from the carboxy groups of said interpolymer: (A) from about 20 to about 70 mole % based on moles of carboxyl groups in said interpolymer, of ester groups containing from about 13 to about 19 carbon atoms; (B) from about 80 to about 30 mole %, based on moles of carboxyl groups in said interpolymer, of ester groups containing from about 8 to about 12 carbon atoms, optionally; (C) up to about 20 mole %, based on moles of carboxyl groups in said interpolymer, of ester groups containing from 2 to 7 carbon atoms; wherein from about 93 to about 97% of the carboxy groups derived from the carboxy-containing interpolymer are ester groups, the balance of the carboxy groups comprising residual carboxylic acid or anhydride groups which are then (D) reacted with at least one amino compound having an average of from 1 to about 1.1 primary or secondary amino groups, to convert from about 5 up to less than 50% of the carboxylic acid or anhydride groups to carbonyl-amino groups, with the unreacted carboxylic acid or anhydride groups remaining as (E) residual carboxylic acid or anhydride groups.

Examples

[0053] The invention will be further illustrated by the following examples, which set forth particularly advantageous embodiments. While the examples are provided to illustrate the invention, they are not intended to limit it.

Example Set A

[0054] A set of examples of industrial gear lubricants is prepared in group II base oil. Each example uses the same base oil and the same industrial gear lubricant additive package. Some examples then include a supplemental additive in order to evaluate the impact the supplement has on the operating temperature seen when an industrial gearbox is operated with the prepared industrial gear lubricants. The examples are summarized in the table below. Different amounts of the different supplemental additives used in the examples reflect the different phosphorus levels of each material. Amounts were adjusted so the same amount of phosphorus was delivered when changing from one supplemental additive to another.

Table 1

	Ex A-1	Ex A-2	Ex A-3	Ex A-4	Ex A-5	Ex A-6	Ex A-7	Ex A-8	Ex A-9
Group II Base Oil[1]	98.0	97.0	96.25	95.5	96.25	95.5	96.42	95.74	95.43

(continued)

	Ex A-1	Ex A-2	Ex A-3	Ex A-4	Ex A-5	Ex A-6	Ex A-7	Ex A-8	Ex A-9
IGO Add Pack[2]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
C18 Phosphite[3]		1.0	1.75	2.5					
C16-18 Phosphite[4]					1.75	2.5			
C16-18 Phosphonate[5]							1.58	2.26	
Phos acid amine salt[6]									2.57
Gearbox Operating Temperature (°C)[7]	149	144	144	141	149	139	146	145	147
Change from A-1 Baseline (°C)[7]	--	-5	-5	-8	0	-10	-3	-4	-2

1 - All the examples in this set use a Group II ISO 150 base oil, which is a mixture of a 600N RLOP base oil and polyisobutylene.
2 - All the examples in this set use the same industrial gear oil additive package which includes a sulfurized olefin, a thiophosphate ester, a thiadiazole, a tolyltriazole, a polyether, an alkenyl amine, an ester copolymer, a carboxylic ester, and a succinimide dispersant.
3 - The C18 phosphite is a di-alkyl substituted phosphite with C18 alkyl groups.
4 - The C16-18 phosphite is a di-alkyl substituted phosphite with C16-18 alkyl groups.
5 - The C16-18 phosphonate is a di-alkyl substituted phosphonate with C16-18 alkyl groups.
6 - The phos acid amine salt is an amine salt of a C18 alkyl phosphoric acid.
7 - Each example is tested by an internally developed procedure where "C" profile gears are mounted in a test rig, lubricated with the example industrial gear lubricant, operated through a break-in period, and then tested for two hours at 1750 rpm under a 300 Nm load. The temperature of the gearbox is monitored and the reported value is where the temperature stabilized during the test period. A lower temperature compared to the baseline indicates a reduced gearbox operation temperature. These results have been normalized for ambient temperature.

[0055] The results show that the industrial gear lubricants of the present invention provide a reduction in operating temperature in industrial gearboxes. The data shows this benefit is obtained using multiple fatty phosphites and that the level of reduction depends on the base medium used.

Example Set B

[0056] An additional set of examples of industrial gear lubricants is prepared in various other base oils. The examples are summarized in the table below.

Table 2

	Ex B-1	Ex B-2	Ex B-3	Ex B-4	Ex B-5	Ex B-6	Ex B-7	Ex B-8	Ex B-9
Synthetic Base Oil 1[1]	98.0	97.0	96.25	95.5	95.5				
Synthetic Base Oil 2[2]						98.0	95.5		
Synthetic Base Oil 3[3]								96.0	94.5
IGO Add Pack[4]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	4.0	4.0
C18 Phosphite[5]		1.0	1.75	2.5			2.5		1.5

(continued)

	Ex B-1	Ex B-2	Ex B-3	Ex B-4	Ex B-5	Ex B-6	Ex B-7	Ex B-8	Ex B-9
C16-18 Phosphite[6]					2.5				
Gearbox Operating Temperature (°C)[7]	140	123	125	138	137	143	133	150	143
Change from B-1 Baseline (°C)[7]	--	-13	-15	-2	-3	--	-10	--	-7

1 - Examples B-1, B-2, B-3, B-4, and B-5 use synthetic ISO 150 base oil which is a mix of PAOs
2 - Examples B-6 and B-7 use synthetic ISO 150 base oil which is a mix of PAOs and an alkyl ester copolymer.
3 - Examples B-8 and B-9 use synthetic ISO 320 base oil which is a mix of PAOs and an alkyl ester copolymer.
4 - All the examples in this set, except B-8 and B-9, use the same industrial gear oil additive package used in Example Set A. Examples B-8 and B-9 use a different industrial gear oil additive package that contains the same components as the package used in Example Set A but in different amounts.
5 - The C18 phosphite is a di-alkyl substituted phosphite with C18 alkyl groups,
6 - The C16-18 phosphite is a di-alkyl substituted phosphite with C16-18 alkyl groups.
7 - Each example is tested by an internally developed procedure where "C" profile gears are mounted in a test rig, lubricated with the example industrial gear lubricant, operated through a break-in period, and then tested for two hours at 1750 rpm under a 300 Nm load. The temperature of the gearbox is monitored and the reported value is where the temperature stabilized during the test period. A lower temperature compared to the baseline indicates a reduced gearbox operation temperature.

[0057] The results show that the industrial gear lubricants provide a reduction in operating temperature in industrial gearboxes. The data shows this benefit is obtained across multiple base oils as well as different industrial gear additive packages.

[0058] Except in the Examples, or where otherwise indicated, all numerical quantities in this description specifying amounts, reaction conditions, molecular weights, number of carbon atoms, etc., are to be understood as modified by the word "about." Unless otherwise indicated, all percent and formulation values are on a weight basis. Unless otherwise indicated, all molecular weights are number average molecular weights. Unless otherwise indicated, each chemical or composition referred to herein should be interpreted as being a commercial grade material which may contain the isomers, byproducts, derivatives, and other such materials which are normally understood to be present in the commercial grade. However, the amount of each chemical component is presented exclusive of any solvent or diluent, which may be customarily present in the commercial material, unless otherwise indicated. It is to be understood that the upper and lower amount, range, and ratio limits set forth herein may be independently combined. Similarly, the ranges and amounts for each element of the invention can be used together with ranges or amounts for any of the other elements. As used herein, the expression "consisting essentially of' permits the inclusion of substances that do not materially affect the basic and novel characteristics of the composition under consideration. All of the embodiments of the invention described herein are contemplated from and may be read from both an open-ended and inclusive view (i.e. using "comprising of' language) and a closed and exclusive view (i.e., using "consisting of' language).

[0059] As used herein, the term "hydrocarbyl substituent" or "hydrocarbyl group" is used in its ordinary sense, which is well-known to those skilled in the art. Specifically, it refers to a group having a carbon atom directly attached to the remainder of the molecule and having predominantly hydrocarbon character. Examples of hydrocarbyl groups include: (i) hydrocarbon substituents, that is, aliphatic (e.g., alkyl or alkenyl), alicyclic (e.g., cycloalkyl, cycloalkenyl) substituents, and aromatic-, aliphatic-, and alicyclicsubstituted aromatic substituents, as well as cyclic substituents wherein the ring is completed through another portion of the molecule (e.g., two substituents together form a ring); (ii) substituted hydrocarbon substituents, that is, substituents containing non-hydrocarbon groups which, in the context of this invention, do not alter the predominantly hydrocarbon nature of the substituent (e.g., halo (especially chloro and fluoro), hydroxy, alkoxy, mercapto, alkylmercapto, nitro, nitroso, and sulfoxy); (iii) hetero substituents, that is, substituents which, while having a predominantly hydrocarbon character, in the context of this invention, contain other than carbon in a ring or chain otherwise composed of carbon atoms and encompass substituents such as pyridyl, furyl, thienyl and imidazolyl. Heteroatoms include sulfur, oxygen, and nitrogen. In general, no more than two, or no more than one, non-hydrocarbon substituent will be present for every ten carbon atoms in the hydrocarbyl group; alternatively, there may be no non-hydrocarbon substituents in the hydrocarbyl group.

[0060] It is known that some of the materials described above may interact in the final formulation, so that the com-

ponents of the final formulation may be different from those that are initially added. For instance, metal ions (of, e.g., a detergent) can migrate to other acidic or anionic sites of other molecules. The products formed thereby, including the products formed upon employing the composition in its intended use, may not be capable of easy description.

Claims

1. Use of a fatty phosphite for reducing the operating temperature of an industrial gearbox, said use comprising the steps of: (I) adding to an industrial gear oil lubricant comprising

   (a) an oil of lubricating viscosity, and (b) an industrial gear lubricant additive package,
   (c) a fatty phosphite such that the lubricant contains at least 1.0 percent by weight fatty phosphite, and (II) operating the industrial gearbox while supplying the industrial gear oil lubricant to the industrial gearbox, wherein (b) the industrial gear lubricant additive package comprises one or more antiwear additives and/or extreme pressure agents, one or more rust and/or corrosion inhibitors, one or more foam inhibitors, one or more demulsifiers, or any combination thereof.

2. The use of claim 1 wherein at least a portion of the fatty phosphite is added to the industrial gear oil lubricant before the lubricant is supplied to the industrial gearbox.

3. The use of claim 1, wherein at least a portion of the fatty phosphite is added to the industrial gear oil lubricant after the lubricant is supplied to the industrial gearbox.

4. The use of any preceding claim 1 to 3 wherein component (a), the oil of lubricating viscosity, comprises a group I base oil, a group II base oil, a group III base oil, a synthetic base oil, or any combination thereof.

5. The use of any preceding claim 1 to 4 wherein component (b), the industrial gear lubricant additive package, comprises: one or more sulfurized olefins; one or more phosphorus amine salts; one or more thiophosphate esters, one or more thiadiazoles, tolyltriazoles, polyethers, and/or alkenyl amines; one or more ester copolymers; one or more carboxylic esters; one or more succinimide dispersants; or any combination thereof.

6. The use of any preceding claim 1 to 5 wherein the industrial gear oil lubricant is an industrial gear additive concentrate containing up to 40 percent by weight of component (a).

7. The use of any preceding claim 1 to 6, wherein the industrial gear oil lubricant contains at least 80 percent by weight of component (a).

8. The use of claim 7 wherein component (c) is present from 1.0 to 10.0 percent by weight of the overall industrial gear lubricant.

Patentansprüche

1. Verwendung eines Fettphosphits zum Verringern der Betriebstemperatur eines Industriegetriebes, wobei die Verwendung die folgenden Schritte umfasst: (I) Zugeben zu einem Industriegetriebeölschmiermittel, das (a) ein Öl mit Schmierviskosität und (b) ein Industriegetriebeschmiermittel-Additivpaket umfasst, (c) eines Fettphosphits, derart, dass das Schmiermittel wenigstens 1,0 Gewichtsprozent Fettphosphit enthält, und (II) Betreiben des Industriegetriebes, während dem Industriegetriebe das Industriegetriebeölschmiermittel zugeführt wird, wobei (b) das Industriegetriebeschmiermittel-Additivpaket ein oder mehrere Verschleißschutzadditive und/oder Hochdruckmittel, einen oder mehrere Rost- und/oder Korrosionsinhibitoren, einen oder mehrere Schauminhibitoren, einen oder mehrere Demulgatoren oder eine beliebige Kombination davon umfasst.

2. Verwendung nach Anspruch 1, wobei dem Industriegetriebeölschmiermittel wenigstens ein Anteil des Fettphosphits zugegeben wird, bevor dem Industriegetriebe das Schmiermittel zugeführt wird.

3. Verwendung nach Anspruch 1, wobei dem Industriegetriebeölschmiermittel wenigstens ein Anteil des Fettphosphits zugegeben wird, nachdem dem Industriegetriebe das Schmiermittel zugeführt worden ist.

4. Verwendung nach einem der vorhergehenden Ansprüche 1 bis 3, wobei Komponente (a), das Öl mit Schmierviskosität, ein Grundöl der Gruppe I, ein Grundöl der Gruppe II, ein Grundöl der Gruppe III, ein synthetisches Grundöl oder eine beliebige Kombination davon umfasst.

5. Verwendung nach einem der vorhergehenden Ansprüche 1 bis 4, wobei Komponente (b), das Industriegetriebeschmiermittel-Additivpaket, Folgendes umfasst: ein oder mehrere schwefelhaltige Olefine; ein oder mehrere Phosphoraminsalze; ein oder mehrere Thiophosphatester, ein oder mehrere Thiadiazole, Tolyltriazole, Polyether und/oder Alkenylamine; ein oder mehrere Estercopolymere; ein oder mehrere Carbonsäureester; ein oder mehrere Succinimiddispergiermittel; oder eine beliebige Kombination davon.

6. Verwendung nach einem der vorhergehenden Ansprüche 1 bis 5, wobei das Industriegetriebeölschmiermittel ein Industriegetriebeadditivkonzentrat, das bis zu 40 Gewichtsprozent von Komponente (a) enthält, ist.

7. Verwendung nach einem der vorhergehenden Ansprüche 1 bis 6, wobei das Industriegetriebeölschmiermittel wenigstens 80 Gewichtsprozent von Komponente (a) enthält.

8. Verwendung nach Anspruch 7, wobei Komponente (c) von 1,0 bis 10,0 Gewichtsprozent des gesamten Industriegetriebeschmiermittels vorliegt.

Revendications

1. Utilisation d'un phosphite gras destiné à réduire la température de fonctionnement d'une boîte de vitesses industrielle, ladite utilisation comprenant les étapes consistant à : (I) ajouter à un lubrifiant à l'huile pour engrenages industriel comprenant (a) une huile de viscosité lubrifiante, et (b) un ensemble d'additifs pour lubrifiant pour engrenages industriels, (c) un phosphite gras de telle sorte que le lubrifiant contient au moins 1,0 % en poids de phosphite gras, et (II) faire fonctionner la boîte de vitesses industrielle tout en fournissant le lubrifiant à l'huile pour engrenages industriels à la boîte de vitesses industrielle, dans laquelle (b) l'ensemble d'additifs pour lubrifiant pour engrenages industriels comprend un ou plusieurs additifs anti-usure et/ou agents de pression extrême, un ou plusieurs inhibiteurs de rouille et/ou de corrosion, un ou plusieurs inhibiteurs de mousse, un ou plusieurs désémulsifiants, ou toute combinaison de ceux-ci.

2. Utilisation selon la revendication 1, dans laquelle au moins une partie du phosphite gras est ajoutée au lubrifiant à l'huile pour engrenages industriels avant la fourniture du lubrifiant à la boîte de vitesses industrielle.

3. Utilisation selon la revendication 1, dans laquelle au moins une partie du phosphite gras est ajoutée au lubrifiant à l'huile pour engrenages industriels après la fourniture du lubrifiant à la boîte de vitesses industrielle.

4. Utilisation selon l'une quelconque des revendications 1 à 3 précédentes, dans laquelle le composant (a), l'huile de viscosité lubrifiante, comprend une huile de base du groupe I, une huile de base du groupe II, une huile de base du groupe III, une huile de base synthétique, ou toute combinaison de celles-ci.

5. Utilisation selon l'une quelconque des revendications 1 à 4 précédentes, dans laquelle le composant (b), l'ensemble d'additifs pour lubrifiant pour engrenages industriels, comprend : une ou plusieurs oléfines sulfurées ; un ou plusieurs sels d'amine de phosphore ; un ou plusieurs esters de thiophosphate, un ou plusieurs thiadiazoles, tolyltriazoles, polyéthers et/ou alcénylamines ; un ou plusieurs copolymères d'esters ; un ou plusieurs esters carboxyliques ; un ou plusieurs dispersants de succinimide ; ou toute combinaison de ceux-ci.

6. Utilisation selon l'une quelconque des revendications 1 à 5 précédentes, dans laquelle le lubrifiant à l'huile pour engrenages industriels est un concentré d'additifs pour engrenages industriels contenant jusqu'à 40 % en poids de composant (a).

7. Utilisation selon l'une quelconque des revendications 1 à 6, dans laquelle le lubrifiant à l'huile pour engrenages industriels contient au moins 80 % en poids de composant (a).

8. Utilisation selon la revendication 7, dans laquelle le composant (c) est présent à raison de 1,0 à 10,0 % en poids du lubrifiant total pour engrenages industriels.

REFERENCES CITED IN THE DESCRIPTION

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