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(54) Lubrication methods

(57) A method of lubricating a two-stroke, diesel crosshead engine comprises lubricating the engine with a cylinder oil and with a system oil, which oils are different from each other, in which the system oil is an SAE 20 or SAE 30 oil, has a total base number of at least 10 mg KOH/g and comprises :- (a) a base oil; (b) at least one detergent additive in a total amount of detergent corresponding in performance, as measured by the Hot Filtration Test, to at least 1.5 % by weight of the system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group; and (c) at least one anti-wear additive. The method further comprising replenishing the system oil in the engine with a top-up system oil, in which the top-up system oil has the same additives as in the system oil previously charged to the engine but has a viscosity which is lower than that of the system oil previously charged to the engine. The system oil may be prepared by mixing a low detergency system oil with a lubricant concentrate composition which comprises a base oil and at least one detergent additive.

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Description

[0001] This invention relates to lubrication methods and in particular to methods for lubricating two-stroke, diesel crosshead engines.

[0002] Two-stroke, diesel crosshead engines are compression ignition engines in which each piston rod is connected to the crankshaft by a crosshead bearing (sometimes also just referred to as a crosshead). Such engines are usually used in marine applications and sometimes in land-based power generation plants. In two-stroke, diesel crosshead engines, the cylinder liner is lubricated by a cylinder oil which lubricates the inner walls of the cylinder and the piston ring pack and controls corrosive and mechanical wear. The cylinder oil also removes deposits from the outer surfaces of the pistons, and from the piston rings and/or cylinder liners. In two-stroke, diesel crosshead engines, the crankcase is lubricated with a system oil which lubricates the crankshaft, the crosshead, the main bearings, the crosshead bearings and the camshaft and protects the crankcase against corrosion. The system oil also cools the piston undercrown and prevents, reduces or removes deposits from the undercrown area. These two lubricating systems are separated by a barrier (sometimes referred to as a stuffing box) to minimise contamination of the system oil, for example by un-burnt fuel, by by-products of the combustion of the fuel, by used cylinder oil which may have leaked through the stuffing box, or by water which may have leaked from the engine's cooling system.

[0003] Generally, system oils do not have high base numbers or a high neutralisation capacity because the system oil is not generally exposed to acidic by-product gases produced by combustion of the diesel fuel. Generally, system oils do not have very high contaminant-handling performance because generally they are not expected to be subject to any great extent to contamination by un-burnt fuel etc. because of the separation provided by the stuffing box. However, current experience indicates that this is not always the case.

[0004] System oils typically available in the market to date have a viscosity in the SAE30 range typically about 11.5 cSt at 100 °C, and a total base number (sometimes referred to as BN) of typically 6 mg KOH/g or less.

[0005] Whilst such system oils may additionally contain some anti-wear, corrosion-inhibition and/or anti-oxidancy additives, they are generally not well suited to cope with the higher levels of contamination of system oil which are increasingly being encountered in modem crosshead engines, where such contamination may include unburnt fuel, by-products of the combustion of the fuel, used cylinder oil and/or water.

[0006] In use, over time, some of the system oil in the engine is consumed. Normal practice is to top-up the engine with fresh system oil which is the same as that previously charged to the engine. On-line cleaning of the system oil is usually also used. If contamination of the system oil is low, top-up with fresh system oil which is the same as that previously charged to the engine when combined with on-line cleaning may allow the properties of the system oil in the engine to remain within acceptable limits, for example, as defined by the engine designer.

[0007] If contamination of the system oil is too high, partial or complete replacement of the system oil in the engine with fresh system oil which is the same as that previously charged to the engine, may be required to maintain the properties of the system oil in the engine within acceptable limits.

[0008] One property of the system oil in the engine which may require correction is viscosity. This commonly increases during operation of the engine. Usually, partial replacement of the system oil in the engine with fresh system oil of the same viscosity as that previously charged to the engine is used to correct this viscosity increase. However, it is also known, but not common, to use a system oil (sometimes referred to as a cutter oil) which has a viscosity which is less than that of the system oil previously charged to the engine. This may reduce the extent of replacement of the system oil which is required to correct the viscosity increase. For example, according to www/lubmarine.com, ATLANTA MARINE 20 (trade mark) is said to be used to top up crankcase lubrication of slow 2 stroke crosshead diesel engines when the viscosity and the BN of the in service system oil is higher than the warning limit, due to contamination by cylinder lubricant through the stuffing box. It is said that it can be used to regularly top up in order to decrease and to maintain the viscosity at an acceptable level or to replace a part of the in service oil in order to drastically decrease the viscosity below the warning limit. ATLANTA MARINE 20 has a base number of only 2.

[0009] Although a top-up system oil which is added to the engine may have a lower viscosity than that previously charged to the engine, it will generally have the same additives, and in the same concentrations, as those in the system oil which was previously charged to the engine. In some cases, a system oil of the desired viscosity but with no, or relatively low, additive content may be used, for example a base oil or a hydraulic oil. Although these may correct the problem of increasing viscosity of the system oil in the engine, they do not do much to address other aspects of degradation of the performance of the system oil. In particular, they may not address the problem of increased contamination (for example leaked fuel, combustion debris and by-products, and/or waste cylinder oil) in the system oil, which is increasingly being encountered by modem two-stroke, diesel crosshead engines, and which is usually the dominant underlying cause of the viscosity increase.

[0010] With conventional system oils there is often a limit to the number of times one can cut back the viscosity by topping-up and/or partial replacement of the system oil in the engine, because other factors (for example, oil degradation and contamination) will eventually become dominant. This may require complete replacement of the system oil in the engine, even though the viscosity may be within acceptable limits.

[0011] The range within which the viscosity of the system oil in the engine must be maintained is usually quite wide and may permit the viscosity of the system oil in the engine to be allowed to rise considerably above the viscosity of the system oil previously charged to the engine. However, fuel economy benefits may be obtained if the viscosity of the system oil in the engine can be maintained at a low value within the allowable range.

[0012] According to EP-1728849-A a typical system oil has a viscosity at 100°C of 11.5 cSt and a total base number of 5 mg KOH/g (ASTM 2896-98). EP-1728849-A seeks to provide a method of lubricating a cylinder liner and a crankcase in a marine diesel crosshead engine with the same lubricant. This lubricant is said to comprise at least 40 mass % of an oil of lubricating viscosity, at least one detergent, at least one dispersant and at least one anti-wear additive, the lubricating oil composition having a BN, as measured using ASTM D 2896-98, of 10 to 55, preferably 20 to 45, mg KOH/g. Lubricating a crosshead engine with the same lubricant used as both cylinder oil and system oil has disadvantages, one of which at least, is that the properties of that lubricant will be a compromise of properties suited for cylinder oil duties and properties suited for system oil duties, and the oil is therefore not optimised for either duty. For example, according to EP-1728849-A, the lubricating oil composition preferably has a viscosity at 100 °C of 15 to 21 cSt. Such a high viscosity in a system oil is expected to cause poorer fuel economy than would be obtained, for example with a typical system oil having a viscosity at 100°C of 11.5 cSt.

[0013] There is thus a need for a method of lubricating two-stroke diesel engine which avoids or at least mitigates these problems.

[0014] Thus, according to the present invention there is provided a method of lubricating a two-stroke, diesel crosshead engine which method comprises lubricating the engine with a cylinder oil and with a system oil, which oils are different from each other, characterised in that the system oil is an SAE 20 or SAE 30 oil, has a total base number of at least 10 mg KOH/g and comprises :-

(a) a base oil;
(b) at least one detergent additive in a total amount of detergent corresponding in performance, as measured by the Hot Filtration Test, to at least 1.5 % by weight of the system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group; and
(c) at least one anti-wear additive.

[0015] The present invention solves the technical problems identified above by the use of a system oil comprising at least one anti-wear additive and having a defined performance and a defined base number. This can mitigate the problem of increased contamination (for example leaked fuel, combustion debris and by-products, and/or waste cylinder oil) in the system oil which is encountered by modem two-stroke, diesel crosshead engines, and which is usually the dominant underlying cause of the viscosity increase.

[0016] The present invention may be particularly beneficial when the system oil in the engine is partially replaced and/or topped-up to control the properties of the system oil in the engine, for example to control the viscosity of the system oil in the engine.

[0017] Thus, according to a further aspect of the present invention there is provided a method of lubricating a two-stroke, diesel crosshead engine which method comprises lubricating the engine with a cylinder oil and with a system oil, which oils are different from each other, characterised in that the system oil is an SAE 20 or SAE 30 oil, has a total base number of at least 10 mg KOH/g and comprises :-

(a) a base oil;
(b) at least one detergent additive in a total amount of detergent corresponding in performance, as measured by the Hot Filtration Test, to at least 1.5 % by weight of the system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group; and
(c) at least one anti-wear additive,

the method further comprising replenishing the system oil in the engine with a top-up system oil, in which the top-up system oil has the same additives as in the system oil previously charged to the engine but has a viscosity which is lower than that of the system oil previously charged to the engine.

[0018] In this embodiment of the present invention, when the system oil in the engine is topped-up and/or partially replaced with a system oil which has a viscosity which is less than that of the system oil originally charged to the engine, but has the same additives as those in the system oil which was previously charged to the engine, the problem of increasing viscosity of the system oil in the engine can be addressed at the same time as addressing other aspects of degradation of the performance of the system oil, such as the problem of increased contamination (for example leaked fuel, combustion debris and by-products, and/or waste cylinder oil) in the system oil. This may enable the viscosity of the system oil in the engine to be controlled within a range of viscosities which is lower than might otherwise be the case. This can have benefits of fuel economy for the engine.

[0019] The top-up system oil of the present invention has the same additives as those in the system oil which was previously charged to the engine, but in concentrations which independently, may be the same or different to the concentrations in the system oil which was previously charged to the engine.

[0020] The system oil and top-up system oil of the present invention each comprise a base oil. The base oil may comprise at least one basestock selected from the group consisting of Group I basestocks; Group II basestocks; Group III basestocks; basestocks derived from Fischer-Tropsch synthesised, waxy, paraffinic hydrocarbon materials; naphthenic basestocks; mineral basestocks having a viscosity index in the range 40 to 80; and mixtures thereof.

[0021] Basestock groups are defined according to API standard 1509, "ENGINE OIL LICENSING AND CERTIFICATION SYSTEM", November 2004 version 15th edition Appendix E, as set out in Table 1 below :

Table I

Group	Saturated hydrocarbon content (wt%)		Sulphur content (wt%)		Viscosity Index
I	< 90	and/or	> 0.03	and	≥ 80 and < 120
II	≥ 90	and	≤ 0.03	and	≥ 80 and < 120
III	≥ 90	and	≤ 0.03	and	≥ 120
IV	polyalpha olefins				
V	all basestocks not in Groups I, II, III or IV				

[0022] Group I and Group II basestock are derived from mineral oil by known refinery process. Group III basestocks may be derived from mineral oil by refinery processes known in the art. Group III basestocks may also be known as synthetic basestocks and include for example, Shell XHVI (trade mark) and Nexbase (trade mark). Naphthenic basestocks and other mineral oil basestocks may be derived from mineral oil by refinery processes known in the art.

[0023] Basestocks derived from Fischer-Tropsch synthesised, waxy, paraffinic hydrocarbon materials may be made by any suitable known process for the manufacture of basestock from Fischer Tropsch processes. Processes for the manufacture of a basestock derived from Fischer-Tropsch synthesised, waxy, paraffinic hydrocarbon material which may be used, are described for example in US4943672, EP-A-0668342 and EP-A-0776959, the contents of which are hereby incorporated by reference. Thus, the basestock may be made by the steps of (i) producing Syngas, (ii) Fischer-Tropsch synthesis of hydrocarbons from the Syngas, (iii) hydrocracking of the hydrocarbons to produce naphtha and diesel/kerosene fuel process streams together with a waxy paraffinic residue and (iv) hydroisomerising the waxy residue to produce the basestock.

[0024] The system oil and top-up system oil each comprise at least one detergent additive in a total amount of detergent corresponding in performance, as measured by the Hot Filtration Test, to at least 1.5 % by weight of the system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group. Preferably, the system oil and top-up system oil each comprise at least one detergent additive in a total amount of detergent corresponding in performance, as measured by the Hot Filtration Test, to at least 1.75 % by weight of the system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group.

[0025] The detergent additive performance is measured by the Hot Filtration Test. This compares the performance of a test sample against a reference sample. The Hot Filtration Test is a measure of detergency and fuel-contamination handling performance of the detergent additive. The following procedure may be used, the test being performed in duplicate :

1. A representative sample (25 g) of the lubricant to be tested is mixed thoroughly with 5 - 15 % by weight of fuel oil, the amount depending upon the fuel oil quality. The fuel oil must be a residual fuel oil with a viscosity of approximately 380 cSt (measured at 50 °C) and preferably, having a heptane-insoluble asphaltene content measured by IP 143/01 method of between 8 and 10 % by weight.
2. The mixture is mixed thoroughly and the stored for 24 hours at a temperature of 100 °C.
3. A weighed sample of the mixture is then filtered at 100 °C through glass-fibre filter papers in the apparatus as prescribed in IP375/99, with a target filtrate volume equivalent to 10 g of the mixture from step (2).
4. After washing and drying the filters as prescribed in IP 375/99, the weight of sediment captured by the filters is measured and expressed as a percentage of the sample according to IP375/99.
5. The result is expressed as an average of the duplicate tests.
6. The procedure is repeated using a reference lubricant having 1.5 % by weight of the system oil, of a calcium alkyl

salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group;
7. If the average percentage sediment measured for the test system oil is the same or less than that measured for the reference sample, the test system oil is deemed to have a total amount of detergent corresponding in detergency and fuel-contamination handling performance, as measured by the Hot Filtration Test, to at least 1.5 % by weight of the system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group.

[0026] Each of the one or more detergent additives may comprise a metal salt of an acidic organic compound and a base. The metal may be an alkali or alkaline earth metal, for example sodium, potassium, lithium, calcium, barium or magnesium. Mixtures of metal salts may be used. Preferably, the metal is calcium.
[0027] Each of the one or more detergent additives may comprise a metal salt of a carboxylate, a sulphonate, a phenate, a thiophosphate or a naphthenate. Mixtures of salts may be used. A preferred carboxylate is salicylate.
[0028] Preferably, the one or more detergent additives of the present invention comprise calcium phenates, calcium salicylates or mixtures thereof.
[0029] Preferably, the system oil comprises at least one calcium alkyl salicylate detergent additive, in which the alkyl group is a C_{12} to C_{30} alkyl group, in a total amount of at least 1.5 % by weight of the system oil, more preferably at least 1.75 % by weight, of calcium alkyl salicylate detergent soap.
[0030] Preferably, the system oil and top-up system oil each comprise at least one calcium alkyl salicylate detergent additive in which the alkyl group is a C_{12} to C_{30} alkyl group, in a total amount of at least 1.5 % by weight, more preferably at least 1.75 % by weight of the system oil and top-up system oil, of calcium alkyl salicylate detergent soap.
[0031] Each of the one or more detergent additives of the present invention may comprise a complex/hybrid detergent which may be prepared from a mixture of one or more metal surfactants, for example from a mixture of a calcium alkyl phenate and a calcium alkyl salicylate.
[0032] Each of the one or more detergent additives may contain at least one hydrocarbyl group, for example as a substituent on an aromatic ring. The term hydrocarbyl means that the group is primarily composed of hydrogen and carbon atoms and is bonded to the remainder of the compound via a carbon atom, but does not exclude the presence of other atoms or groups in a proportion insufficient to detract from the substantially hydrocarbon characteristics of the group. Advantageously, the alkyl groups have 5 to 100, preferably 7 to 30 carbon atoms.
[0033] Each of the one or more detergent additives may be sulphurised. Processes for sulphurizing are known in the art.
[0034] Each of the one or more detergent additives may be borated. Processes for borating are known in the art.
[0035] Each of the one or more detergent additives may be a neutral detergent, a low based detergent, a low overbased detergent or a high overbased detergent
[0036] Each of the one or more detergent additives may have a total base number in the range of from greater than 0 to 500 mg KOH/g, preferably in the range 25 to 500 mg KOH/g, more preferably in the range of 30 to 300 mg KOH/g.
[0037] Total base numbers may be measured according to ASTM D 2896-98.
[0038] The system oil and top-up system oil each may comprise at least one high base detergent additive in a relatively large amount - for example calcium phenate with a total base number of 400 mg KOH/g in an amount of 5 % by weight.
[0039] The system oil and top-up system oil of the present invention each comprise at least one anti-wear additive. Suitable anti-wear additives include dihydrocarbyl dithiophosphate metal salts. The metals of the dihydrocarbyl dithiophosphate metal salts may be alkali metals, alkaline earth metals, aluminium, lead, tin, molybdenum, manganese, nickel, zinc or copper. Preferably, the system oil and top-up system oil of the present invention each comprise at least one zinc dihydrocarbyl dithiophosphate anti-wear additive. Primary and/or secondary hydrocarbyl groups may be present in the anti-wear additives. The hydrocarbyl groups may be alkyl groups. Each hydrocarbyl group may have 1 to 18 carbon atoms. The total amount of the anti-wear additives in each of the system oil and the top-up system oil of the present invention is preferably in the range, expressed as zinc of up to 1100 ppm zinc. The total amount of the anti-wear additives in each of the system oil and the top-up system oil of the present invention is preferably in the range, expressed as phosphorus of up to 1000 ppm phosphorus, preferably in the range 100 to 600 ppm phosphorus and more preferably in the range of 200 to 400 ppm phosphorus.
[0040] The system oil and top-up system oil of the present invention may also comprise one or more dispersants. Preferably, the dispersants are ashless dispersants. These are non-metallic organic compounds that form substantially no ash on combustion. Each ashless dispersant may comprise a long chain hydrocarbon with a polar head. The polar head may comprise oxygen, phosphorus or nitrogen atoms. The hydrocarbon chain may have 40 to 500 carbon atoms. Suitable ashless dispersants are succinimides, for example polyisobutene succinic anhydride; polyamine condensation products; succinimides, for example polyisobutene succinimides; succinic esters, for example polyisobutene succinic esters; or aminated succinic ester, for example aminated polyisobutene succinic esters. The dispersants may be borated. If present, the total amount of dispersant in each of the system oil and top-up system oil of the present invention may be in the range of from greater than 0 to 3 % by weight, preferably in the range of from greater than 0 to 2 %, more preferably in the range of from greater than 0 to 1 % by weight.
[0041] The system oil and top-up system oil of the present invention may also comprise one or more anti-foam additives.

Typical anti-foam additives which may be used include polydimethyl siloxanes and methacrylates. If present, the total amount of anti-foam additives in each of the system oil and top-up system oil of the present invention may be an amount expressed as silicon, of up to 50 ppm, preferably up to 30 ppm, more preferably up to 15 ppm.

[0042] The system oil and top-up system oil of the present invention may also comprise one or more anti-rust additives. Typical anti-rust additives which may be used include nonyl phenolamine, octyl phenolamine and non-phenol based anti-rust additives, for example alkylene glycols. If present, the total amount of anti-rust additives in each of the system oil and top-up system oil of the present invention may be up to 1 % by weight, preferably up to 0.5 % by weight and more preferably up to 0.2 % by weight.

[0043] The system oil and top-up system oil of the present invention may also comprise one or more pour point depressants. Typical pour point depressants which may be used include polymethacrylate compounds. If present, the total amount of pour point depressants in each of the system oil and top-up system oil of the present invention may be up to 1 % by weight, preferably up to 0.5 % by weight, more preferably up to 0.25 % by weight.

[0044] The system oil and top-up system oil of the present invention may also comprise one or more anti-oxidants in addition to the anti-wear additives and/or detergents, which may also act at least in part as anti-oxidants. Typical anti-oxidants which may be used include phenolic ashless anti-oxidants and aminic ashless anti-oxidants. If present, the total amount of anti-oxidants other than anti-wear additive and/or detergents which act at least in part as anti-oxidants, in each of the system oil and top-up system oil of the present invention may be up to 1 % by weight, preferably up to 0.5 % by weight, more preferably up to 0.2 % by weight.

[0045] The system oil and top-up system oil of the present invention may also comprise one or more friction modifiers. Typical friction modifiers include salicylates; stearates, for example calcium stearate; glycerol mono oleate and oleamides; and natural esters, for example sunflower oil. If present, the total amount of glycerol mono oleate and/or oleamide friction modifiers in each of the system oil and top-up system oil of the present invention may be up to 1 % by weight, preferably up to 0.5 % by weight, more preferably up to 0.2 % by weight. Other friction modifiers may be present at higher concentrations.

[0046] The system oil and top-up system oil for the present invention may each independently have a total base number of 10 to 40 mg KOH/g, preferably of 10 to 30 mg KOH/g, more preferably of 15 to 30 mg KOH/g, yet more preferably of 15 to 20 mg KOH/g. Preferably, the system oil and the top-up system oil have the same total base number. The top-up system oil may have a base number which is lower than the system oil previously charged to the engine. The top-up system oil may have a base number which is higher than the system oil previously charged to the engine, for example a top-up system oil with a total base number in the range of 15 - 20 mg KOH/g may be used with a system oil previously charged to the engine having a total base number in the range of 10 - 15 mg KOH/g.

[0047] Total base number may be measured according to ASTM D 2896-98.

[0048] The system oil is an SAE 20 or SAE 30 oil. SAE 20 oils have a viscosity at 100 °C in the range of 5.6 to less than 9.3 cSt. SAE 30 oils have a viscosity at 100 °C in the range of 9.3 to less than12.5 cSt. Preferably, the system oil is an SAE 30 oil. However engine designers and manufacturers often specify minimum viscosities of system oil which may be used in the engine. For example, the system oil used in the present invention may have a kinematic viscosity at 100 °C in the range of 7.9 to less than 12.5 cSt, preferably in the range of 8.8 to 11.5 cSt, more preferably in the range of 9.3 to 11.5 cSt.

[0049] The viscosity of the system oil in the engine may be controlled by replenishing the system oil in the engine with a top-up system oil in which the top-up system oil has the same additives and in the same or different concentrations as in the system oil previously charged to the engine but which has a viscosity which is lower than that of the system oil previously charged to the engine.

[0050] In this embodiment of the present invention, the system oil in the engine may be replenished by adding to the engine, top-up system oil to replace system oil which has been consumed or lost from the engine. The system oil in the engine may be replenished by removing part of the system oil from the engine and replacing it with top-up system oil. On-line cleaning may be used in conjunction with partial replacement of the system oil in the engine.

[0051] The top-up system oil may be an SAE 20 or an SAE 30 oil, preferably, the top-up system oil is an SAE 20 oil. Preferably, the top-up system oil has a kinematic viscosity measured at 100 °C which is in the range of 5 to 1 cSt less than that of the system oil previously charged to the engine, preferably in the range of 4 to 2 cSt less than that of the system oil originally charged to the engine.

[0052] The viscosity of the system oil in the engine may be regularly and/or continuously monitored. The viscosity of the system oil in the engine may be continuously monitored for example, with an in-line monitor. Addition of system top-up oil may be controlled by an in-line monitor which continuously monitors the viscosity of the system oil in the engine.

[0053] The system oil of the present invention may be prepared by mixing a low detergency system oil with a lubricant concentrate composition. This mixing may be done external to the engine. If the engine is on a vessel, such external mixing may be performed on-board the vessel. The low detergency system oil may be a conventional system oil. The low detergency system oil, for example a conventional system oil, may be provided in a storage tank on-board a vessel and mixed with a lubricant concentrate composition on-board the vessel. Alternatively or additionally, the mixing may be performed, at least in part, *in situ,* by charging to the engine, a low detergency system oil (for example, a conventional system oil), which may be used or unused, and a lubricant concentrate composition. Thus, the engine may have been charged with a low detergency system oil (for example a conventional system oil), which may be used or unused, and lubricant concentrate composition may charged to the engine to mix with the low detergency system oil. Part of the low detergency system oil in the engine may be removed to provide space for the lubricant concentrate composition. Thus, according to an embodiment of the present invention, a lubricant concentrate composition is charged to an engine which contains used or unused low detergency system oil (for example a conventional system oil), part of which optionally, has been removed, whereby the low detergency system oil and the lubricant concentrate composition mix to provide a system oil according to the present invention. In particular, according to an embodiment of the present invention, a lubricant concentrate composition is charged to an engine which contains used low detergency system oil (for example a conventional system oil), part of which has been removed, whereby the low detergency system oil and the lubricant concentrate composition mix to provide a system oil according to the present invention. When at least part of the low detergency system oil is removed, this may be treated, for example in a settling tank to remove preferentially, solids, water and/or other undesirably contaminants.

[0054] The lubricant concentrate composition comprises a base oil and at least one detergent additive. Preferably, the lubricant concentrate composition also comprises at least one anti-wear additive.

[0055] The lubricant concentrate composition comprises at least one detergent additive of a type and in an amount such as to provide a system oil according to the present invention when mixed with the low detergency system oil. Thus, the lubricant concentrate composition has a higher concentration of detergent additive or additives than that of the low detergency system oil and also a higher concentration than that which will be present in the system oil according to the present invention which is prepared by mixing the low detergency system oil and the lubricant concentrate composition.

[0056] Preferably, the lubricant concentrate composition also comprises at least one antiwear additive which is of the same type as those hereindescribed with respect to the system oil according to the present invention and in an amount such as to provide a system oil according to the present invention when mixed with the low detergency system oil.

[0057] The lubricant concentrate composition may also comprise one or more additives selected from the group consisting of dispersants, anti-foam additives, anti-rust additives, pour point depressants, anti-oxidants, friction modifiers and combinations thereof. These additives may independently be of the same type as those hereindescribed with respect to the system oil according to the present invention. These additives are present in the lubricant concentrate composition in an amount sufficient to provide the required concentrations in the system oil according to the present invention.

[0058] Suitably, the lubricant additive concentrate has a base number which is greater than the base number of the system oil according to the present invention. Preferably, the lubricant concentrate composition has a base number of at least 20 mg KOH/g, more preferably at least 25 mg KOH/g. Preferably, the additive concentrate has a base number of up to 200 mg KOH/g, more preferably of up to 150 mg KOH/g. More preferably, the additive concentrate has a base number in the range 20 to 200 mg KOH/g, yet more preferably in the range 25 to 150 mg KOH/g.

[0059] The lubricant concentrate composition may comprise a base oil which is the same type as that hereindescribed with respect to the system oil according to the present invention. Suitable base oils include 150N and 350N base oils. The lubricant concentrate composition may comprise a solvent or diluent, for example a cutter oil which is a base oil having a low viscosity. Preferably, the base oil is present in the lubricant concentrate composition at a concentration of up to 90 % by volume.

[0060] The lubricant concentrate composition may have a kinematic viscosity which is less than that of the low detergency system oil. This has an advantage, for example when the low detergency system oil is a used oil and the lubricant concentrate composition is to be mixed with the used low detergency system oil in the engine, because the lubricant concentrate composition can also reduce the viscosity of the used low detergency system oil, which for example might have increased from that of the system oil previously charged to the engine by use. Suitably, the lubricant concentrate composition has a kinematic viscosity at 100 °C in the range 5 cSt to 12 cSt.

[0061] A preferred lubricant concentrate composition has a base number of 20 to 200 mg KOH/g, preferably of 25 to 150 mg KOH/g, and a kinematic viscosity at 100 °C of 5 cSt to 12 cSt.

[0062] A suitable lubricant concentrate composition comprises a base oil, one or more detergents (for example selected from one or more salicylate detergents, phenate detergents and combinations thereof) and one or more additives selected from antiwear additives, dispersants, corrosion inhibitors and combinations thereof. Such a lubricant concentrate composition may have a base number of 20 to 200 mg KOH/g, preferably of 25 to 150 mg KOH/g, and a kinematic viscosity at 100 °C of 5 cSt to 12 cSt.

[0063] The lubricant concentrate composition and the low detergency system oil may be mixed in ratios by volume ranging from 5 : 95 to 50 : 50 of lubricant concentrate composition : low detergency system oil, for example in a ratio by volume of 25 : 75 lubricant concentrate composition : low detergency system oil.

[0064] More preferably, the lubricant concentrate composition has a base number of 25 to 150 mg KOH/g and a kinematic viscosity at 100 °C of 5 cSt to 12 cSt, and is mixed with the low detergency system oil in ratios by volume ranging from 5 : 95 to 50 : 50 of lubricant concentrate composition : low detergency system oil, for example in a ratio by volume of 25 : 75 lubricant concentrate composition : low detergency system oil.

[0065] The low detergency system oil may be a conventional system oil, known in the art.

[0066] The low detergency system oil may comprise a smaller amount of detergent additive than is present in the system oil according to the present invention. The low detergency system oil may comprise at least one detergent in a total amount of detergent corresponding in performance, as measured by the Hot Filtration Test, to less than 1.5 % by weight of the low detergency system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group. The detergent or detergents present in the low detergency system oil may be the same type as those hereindescribed with respect to the system oil according to the present invention.

[0067] The low detergency system oil may be an SAE 20 or SAE 30 oil. The low detergency system oil may have a base number in the range 2 to 20 mg KOH/g.

[0068] The low detergency system oil may comprise a base oil which is the same type as that hereindescribed with respect to the system oil according to the present invention.

[0069] The low detergency system oil may comprise at least one anti-wear additive. The anti-wear additive or additives may be the same type as those hereindescribed with respect to the system oil according to the present invention. The anti-wear additives may be present in the low detergency system oil in a total amount which is the same as, less than or more than that in the system oil according to the present invention.

[0070] The low detergency system oil may also comprise one or more additives selected from the group consisting of dispersants, anti-foam additives, anti-rust additives, pour point depressants, anti-oxidants, friction modifiers and combinations thereof. These additives may independently, be the same type as those hereindescribed with respect to the system oil according to the present invention.

[0071] A suitable low detergency system oil is OE-HT30 (trade mark) available from BP Marine Limited, or CDX 30 (Trade Mark) available from Castrol Limited.

[0072] An advantage of using a lubricant concentrate composition to prepare the system oil according to the present invention is that it enables a system oil to be prepared using a low detergency system oil, for example a conventional system oil. Thus, unused low detergency system oil, for example in a storage tank on-board a vessel, and/or used low detergency system oil, for example in an engine, can be used to make a system oil according to the present invention. This can reduce wastage of the low detergency system oil, which need not be discarded when changing to the system oil of the present invention.

[0073] The cylinder oil may be any cylinder oil known in the art. Preferably, the cylinder oil is an SAE 50 oil. Suitable cylinder oils include Castrol Cyltech 50S (trade mark), Castrol Cyltech 80AW (trade mark), Castrol Cyltech 70 (trade mark), Castrol Cyltech 40 SX (trade mark), BP Energol CLO 50M (trade mark), BP Energol CL-DX 405 (trade mark) and BP Energol CL 505 (trade mark).

[0074] The methods of the present invention are used for lubricating a two-stroke, diesel crosshead engine. The diesel engine may be marine or land based.

[0075] The invention will now be described with respect to the following example. A system oil for use in the present invention was prepared using a mixture of Group I basestocks. This system oil comprised zinc dihydrocarbyl dithiophosphate anti-wear additive and had a concentration of salicylate and phenate detergents which will correspond in performance, as measured by the Hot Filtration Test, to at least 1.5 % by weight of the system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group.

[0076] The system oil was manufactured to a specification which included the features of :

- a kinematic viscosity at 100 °C as measured according to ASTM D445, in the range of 11.0 to 12.0 cSt;
- a total base number as measured according to ASTM D2896 in the range of 29.0 to 32.1 mg KOH/g and
- a zinc content as measured by IP308 in the range of 370 to 420 ppm by weight.

[0077] The system oil was used to lubricant a MAN B &W model 6L 70MC Mk6 marine diesel crosshead engine having a power of 16980 KW at 108 rpm. It was operated with a load of 12917 KW at 103 rpm and 76 to 78 % of its Maximum Continuous Rating.

[0078] An interim inspection of the engine and its oil system was carried out after 1464 hours of engine operation, 3 months into service and this showed the performance of the oil to be satisfactory.

[0079] It is anticipated that with use, the viscosity of the system oil will increase and/or some of the system oil will be lost and/or consumed in the engine. The system oil in the engine may be replenished with a top-up system oil, which has the same additives, in the same or different concentrations as in the system oil previously charged to the engine but which has a viscosity which is lower than that of the system oil previously charged to the engine. A suitable top-up system oil might be an SAE 30 with a kinematic viscosity at 100°C of less than 11.5 cSt. A suitable top-up system oil might be an SAE 20 oil.

[0080] It is anticipated that the system oil may be prepared by mixing a low detergency system oil with a lubricant concentrate composition, which lubricant concentrate composition comprises a base oil and at least one detergent additive.

Claims

1. A method of lubricating a two-stroke, diesel crosshead engine which method comprises lubricating the engine with a cylinder oil and with a system oil, which oils are different from each other, **characterised in that** the system oil is an SAE 20 or SAE 30 oil, has a total base number of at least 10 mg KOH/g and comprises :-

   (a) a base oil;
   (b) at least one detergent additive in a total amount of detergent corresponding in performance, as measured by the Hot Filtration Test, to at least 1.5 % by weight of the system oil, of a calcium alkyl salicylate detergent soap in which the alkyl group is a C_{12} to C_{30} alkyl group; and
   (c) at least one anti-wear additive.

2. A method as claimed in claim 1 in which system oil has a total base number of 10 to 40 mg KOH/g, preferably of 10 to 30 mg KOH/g, more preferably of 15 to 30 mg KOH/g, yet more preferably of 15 to 20 mg KOH/g.

3. A method as claimed in claim 1 or claim 2 in which the system oil has a kinematic viscosity at 100 °C in the range of 7.9 to less than 12.5 cSt, preferably in the range of 8.8 to 11.5 cSt, more preferably in the range of 9.3 to 11.5 cSt.

4. A method as claimed in any one of the preceding claims in which the system oil comprises at least one calcium alkyl salicylate detergent additive, in which the alkyl group is a C_{12} to C_{30} alkyl group, in a total amount of at least 1.5 % by weight of the system oil, more preferably at least 1.75 % by weight, of calcium alkyl salicylate detergent soap.

5. A method as claimed in any one of the preceding claims in which the method further comprising replenishing the system oil in the engine with a top-up system oil, in which the top-up system oil has the same additives as in the system oil previously charged to the engine but has a viscosity which is lower than that of the system oil previously charged to the engine.

6. A method as claimed in claim 5 in which the top-up system oil has a total base number of 10 to 40 mg KOH/g, preferably of 10 to 30 mg KOH/g, more preferably of 15 to 30 mg KOH/g, yet more preferably of 15 to 20 mg KOH/g.

7. A method as claimed in claim 5 or claim 6 in which the top-up system oil and the system oil previously charged to the engine have the same base number.

8. A method as claimed in any one of claims 5 to 7 in which the top-up system oil is an SAE 20 or an SAE 30 oil.

9. A method as claimed in any one of claims 5 to 8 in which the top-up system oil has a kinetic viscosity measured at 100 °C which is in the range of 5 to 1 cSt less than that of the system oil previously charged to the engine, preferably in the range of 4 to 2 cSt less than that of the system oil previously charged to the engine.

10. A method as claimed in any one of claims 5 to 9 in which the system oil and the top-up system oil comprise at least one calcium alkyl salicylate detergent additive, in which the alkyl group is a C_{12} to C_{30} alkyl group, in a total amount of at least 1.5 % by weight of the system oil, more preferably at least 1.75 % by weight, of calcium alkyl salicylate detergent soap.

11. A method as claimed in any one of the preceding claims in which the system oil is prepared by mixing a low detergency system oil with a lubricant concentrate composition which lubricant concentrate composition comprises a base oil and at least one detergent additive of a type and in an amount such as to provide a system oil as defined in any one of the preceding claims when mixed with the low detergency system oil.

12. A method as claimed in claim 11 in which the engine is on a vessel and the mixing is performed on-board the vessel and external to the engine.

13. A method as claimed in claim 12 in which alternatively or additionally, the mixing is performed, at least in part, *in situ,* by charging to the engine a low detergency system oil and a lubricant concentrate composition.

14. A method as claimed in any one of claims 11 to 13 in which the lubricant concentrate composition has a base number of at least 20 mg KOH/g, preferably of at least 25 mg KOH/g.

15. A method as claimed in any one of claims 11 to 14 in which the lubricant concentrate composition has a base number of up to 200 mg KOH/g, preferably of up to 150 mg KOH/g.

16. A method as claimed in any one of claims 11 to 15 in which the lubricant concentrate composition has a kinematic viscosity at 100 °C of 5 cSt to 12 CSt.

17. A method as claimed in any one of claims 11 to 16 in which the lubricant concentrate composition and the low detergency system oil are mixed in ratios ranging from 5 : 95 to 50 : 50 of lubricant concentrate composition : low detergency system oil.

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EUROPEAN SEARCH REPORT

Application Number
EP 07 25 2371

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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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C10M
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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	17 January 2008	Bertrand, Samuel

CATEGORY OF CITED DOCUMENTS

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