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(54) **Lubricant composition**

Schmiermittelzusammensetzung

Composition d'huile lubrifiante

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Description

[0001] This invention concerns a lubricant composition, in particular, a marine diesel cylinder lubricant (MDCL) composition. Marine diesel cylinder lubricant compositions are total loss lubricants and their purpose is to provide a strong oil film between the cylinder liner and the piston rings and to neutralise acids formed by combustion of sulphur compounds in the fuel.

[0002] Fuels used for diesel engines generally have a high sulphur content (such as, for example, at least 3.5% sulphur), which results in exhaust gases from diesel engines containing large amounts of sulphur oxides (SO_x). The sulphur oxides react with moisture also present in the exhaust gases to form sulphuric acid which corrodes the engine. Marine diesel cylinder lubricant compositions therefore include overbased metallic detergents to neutralise the sulphuric acid. Commercial marine diesel cylinder lubricant compositions generally have a total base number ('TBN') of at least 70 (as determined using ASTM D2896). Environmental concerns have prompted many areas, such as coastal areas, to require the use of low sulphur fuels, i.e. fuels including less than 1.00% by weight of sulphur, which allows the use of marine diesel cylinder lubricant compositions having lower total base numbers such as, for example, 40. This therefore creates the need for ships to carry tanks for two different lubricants.

[0003] US 4,842,755 discloses a marine diesel cylinder lubricant having a base number of at least 60. The composition includes a borated ashless dispersant, one or more overbased metal compounds and a zinc dialkyl dithiophosphate providing 0.02 to 0.023 wt% (200-230 ppm) of zinc (see claim 1). The specific examples show that increasing the amount of zinc above 230 ppm results in a loss in performance benefits in ring and liner wear.

[0004] EP1 298 189 discloses lubricating composition comprising a Mo-compound, a detergent derived from sulfonate and phenate surfactants and a boron containing dispersant.

[0005] An aim of the present invention is to provide a marine diesel cylinder lubricant composition having a total base number of at least 35 or more (ASTM D 2896-01), that is suitable for use with both high and low sulphur fuels. A further aim of the present invention is to provide a marine diesel cylinder lubricant composition having a total base number of at least 35 or more (ASTM D 2896-01) that is suitable for use with both high and low sulphur fuels, whilst still providing the required level of protection against corrosive wear when used with a high sulphur fuel.

[0006] In accordance with the present invention there is provided a marine diesel cylinder lubricant composition having a total base number, as determined according to ASTM D2896, of at least 35 or more, and comprising:

- at least 40 wt%, based on the total amount of the marine diesel cylinder lubricant composition, of an oil of lubricating viscosity,
- at least one detergent prepared from at least two surfactants, phenate and sulphonate surfactants,
- at least one boron-containing dispersant providing at least 100 ppm of boron, and
- at least one zinc-containing antiwear additive, preferably a zinc dihydrocarbyl dithiophosphate, providing more than 230 ppm, preferably at least 250 ppm, of zinc.

[0007] The inventors have surprisingly found, considering the teachings of US 4,842,755, that in a marine diesel cylinder lubricant composition including a detergent prepared from at least two surfactants, the use of more than 230 ppm zinc provides increased protection against wear.

[0008] The inventors have also found that the marine diesel cylinder lubricant composition defined above provides a good level of wear protection even at a low total base number, such as, for example, 40, when used with a high sulphur fuel.

[0009] In accordance with the present invention there is also provided a method of operating a marine diesel engine, the method including the step of using the marine diesel cylinder lubricant composition defined above to lubricate the engine.

[0010] In accordance with the present invention there is also provided use of the marine diesel cylinder lubricant composition defined above to reduce wear in a marine diesel engine.

Oil of Lubricating Viscosity

[0011] The oil of lubricating viscosity (sometimes referred to as lubricating oil) may be any oil suitable for the lubrication of a marine engine. The lubricating oil may suitably be an animal, a vegetable or a mineral oil. Suitably the lubricating oil is a petroleum-derived lubricating oil, such as a naphthenic base, paraffinic base or mixed base oil. Alternatively, the lubricating oil may be a synthetic lubricating oil. Suitable synthetic lubricating oils include synthetic ester lubricating oils, which oils include diesters such as di-octyl adipate, di-octyl sebacate and tridecyl adipate, or polymeric hydrocarbon lubricating oils, for example liquid polyisobutene and poly-alpha olefins. Commonly, a mineral oil is employed. The lubricating oil may generally comprise greater than 60, typically greater than 70, mass % of the composition, and typically have a kinematic viscosity at 100°C of from 2 to 40, for example for 3 to 15, mm^2s^{-1} and a viscosity index of from 80 to 100, for example from 90 to 95.

[0012] Another class of lubricating oils is hydrocracked oils, where the refining process further breaks down the middle and heavy distillate fractions in the presence of hydrogen at high temperatures and moderate pressures. Hydrocracked oils typically have a kinematic viscosity at 100°C of from 2 to 40, for example from 3 to 15, mm²s⁻¹ and a viscosity index typically in the range of from 100 to 110, for example from 105 to 108.

[0013] The oil may include 'brightstock' which refers to base oils which are solvent-extracted, de-asphalted products from vacuum residuum generally having a kinematic viscosity at 100°C of from 28 to 36 mm²s⁻¹ and are typically used in a proportion of less than 40, preferably less than 30, more preferably less than 20, mass %, based on the mass of the composition.

[0014] The marine diesel cylinder lubricant composition preferably includes at least 50 wt% of oil of lubricating viscosity, more preferably at least 60 wt% of oil of lubricating viscosity, even more preferably at least 70 wt% of oil of lubricating viscosity, based on the total amount of the marine diesel cylinder lubricant composition.

Detergent including at least two Surfactants

[0015] A detergent is an additive that reduces formation of piston deposits, for example high-temperature varnish and lacquer deposits, in engines; it has acid-neutralising properties and is capable of keeping finely divided solids in suspension. It is based on metal "soaps", that is metal salts of acidic organic compounds, sometimes referred to as surfactants.

[0016] The detergent comprises a polar head with a long hydrophobic tail. Large amounts of a metal base are included by reacting an excess of a metal compound, such as an oxide or hydroxide, with an acidic gas such as carbon dioxide to give an overbased detergent which comprises neutralised detergent as the outer layer of a metal base (e.g. carbonate) micelle.

[0017] The detergent includes at least two surfactants, at least phenate and sulphonate surfactants. The detergent may be referred to as a complex/hybrid detergent. The complex detergent preferably includes at least 5 mass% of phenate, more preferably at least 10 mass% of phenate, based on the total amount of the detergent. The complex detergent preferably includes at least 5 mass% of sulphonate, more preferably at least 8 mass% of sulphonate, based on the total amount of the detergent. The detergent preferably also includes a salicylate surfactant. The detergent preferably includes at least 5 mass% of salicylate, more preferably at least 10 mass% of salicylate, based on the total amount of the detergent. The amount of surfactant in the complex detergent can be determined using techniques such as chromatography, spectroscopy and/or titration, well known to persons skilled in the art. The detergent may also include other surfactants such as, for example, a thiophosphate, a naphthenate, or an oil-soluble carboxylate. The surfactant groups are incorporated during the overbasing process. The metal may be an alkali metal or an alkaline earth metal such as sodium, potassium, lithium, calcium and magnesium. Calcium is preferred.

[0018] Examples of complex detergents are described in WO 97/46643, WO 97/46644, WO 97/46645, WO 97/46646 and WO 97/46647.

[0019] Preferably, the detergent has a TBN in the range of 250 to 500, more preferably 280 to 480, even more preferably 300 to 450.

[0020] The marine diesel cylinder lubricant composition preferably includes at least 2 wt%, preferably at least 5 wt%, more preferably at least 8 wt%, of detergent including at least two surfactants, based on the total amount of the marine diesel cylinder lubricant composition.

[0021] The marine diesel cylinder lubricant may also include further detergents such as a calcium phenate detergent, a calcium sulphonate detergent or a calcium salicylate detergent. The further detergent may have a low TBN of less than 50, a medium TBN ranging from 50 to 150 or a high TBN of more than 150. The marine diesel cylinder lubricant composition preferably includes at least 4 wt%, preferably at least 6 wt%, of a further detergent, based on the total amount of the marine diesel cylinder lubricant composition.

Dispersant

[0022] The marine diesel cylinder lubricant composition includes at least one dispersant providing at least 100 ppm of boron. A dispersant is an additive for a lubricating composition whose primary function in cylinder lubricants is to accelerate neutralization of acids by the detergent system.

[0023] A noteworthy class of dispersants are "ashless", meaning a non-metallic organic material that forms substantially no ash on combustion, in contrast to metal-containing, hence ash-forming, materials. Ashless dispersants comprise a long chain hydrocarbon with a polar head, the polarity being derived from inclusion of, e.g., an O, P or N atom. The hydrocarbon is an oleophilic group that confers oil-solubility, having for example 40 to 500 carbon atoms. Thus, ashless dispersants may comprise an oil-soluble polymeric hydrocarbon backbone having functional groups that are capable of associating with particles to be dispersed.

[0024] Examples of ashless dispersants are borated succinimides, e.g. borated polyisobutene succinic anhydride; and polyamine condensation products that are borated.

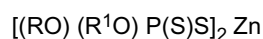
[0025] The marine diesel cylinder lubricant composition preferably includes at least 150 ppm, more preferably at least 200 ppm, of boron, based on the total amount of the marine diesel cylinder lubricant composition.

Antiwear Additive

[0026] The antiwear additive provides at least 230 ppm, preferably at least 250 ppm, of zinc, based on the total amount of the marine diesel cylinder lubricant composition. The antiwear additive preferably provides at least 275 ppm, more preferably at least 300 ppm, even more preferably at least 325 ppm, even more preferably at least 350 ppm, even more preferably at least 375 ppm and most preferably at least 385 ppm, of zinc.

[0027] The antiwear additive may be prepared in accordance with known techniques by firstly forming a dihydrocarbyl dithiophosphoric acid (DDPA), usually by reaction of one or more alcohols or a phenol with P_2S_5 and then neutralizing the formed DDPA with a zinc compound. For example, a dithiophosphoric acid may be made by reacting mixtures of primary and secondary alcohols. Alternatively, multiple dithiophosphoric acids can be prepared comprising both hydrocarbyl groups that are entirely secondary and hydrocarbyl groups that are entirely primary. To make the zinc salt, any basic or neutral zinc compound may be used but the oxides, hydroxides and carbonates are most generally employed. Commercial additives frequently contain an excess of zinc due to use of an excess of the basic zinc compound in the neutralisation reaction.

[0028] The preferred zinc dihydrocarbyl dithiophosphates are oil-soluble salts of dihydrocarbyl dithiophosphoric acids and may be represented by the following formula:



where R and R^1 may be the same or different hydrocarbyl radicals containing from 1 to 18, preferably 2 to 12, carbon atoms and including radicals such as alkyl, alkenyl, aryl, arylalkyl, alkaryl and cycloaliphatic radicals. Particularly preferred as R and R^1 groups are alkyl groups of 2 to 8 carbon atoms. Thus, the radicals may, for example, be ethyl, n-propyl, i-propyl, n-butyl, i-butyl, sec-butyl, amyl, n-hexyl, i-hexyl, n-octyl, decyl, dodecyl, octadecyl, 2-ethylethyl, phenyl, butyl-phenyl, cyclohexyl, methylcyclopentyl, propenyl, butenyl. In order to obtain oil-solubility, the total number of carbon atoms (i.e. in R and R^1) in the dithiophosphoric acid will generally be 5 or greater. The zinc dihydrocarbyl dithiophosphate can therefore comprise zinc dialkyl dithiophosphates.

Anti-oxidants

[0029] The marine diesel cylinder lubricant composition may include at least one anti-oxidant. The anti-oxidant may be aminic or phenolic. As examples of amines there may be mentioned secondary aromatic amines such as diarylamines, for example diphenylamines wherein each phenyl group is alkyl-substituted with an alkyl group having 4 to 9 carbon atoms. As examples of anti-oxidants there may be mentioned hindered phenols, including mono-phenols and bis-phenols.

[0030] Preferably, the anti-oxidant, if present, is provided in the composition in an amount of up to 3 mass %, based on the total amount of the marine diesel cylinder lubricant.

[0031] Other additives such as pour point depressants, anti-foamants, and/or demulsifiers may be provided, if necessary.

[0032] The terms 'oil-soluble' or 'oil-dispersable' as used herein do not necessarily indicate that the compounds or additives are soluble, dissolvable, miscible or capable of being suspended in the oil in all proportions. These do mean, however, that they are, for instance, soluble or stably dispersible in oil to an extent sufficient to exert their intended effect in the environment in which the oil is employed. Moreover, the additional incorporation of other additives may also permit incorporation of higher levels of a particular additive, if desired.

[0033] The lubricant compositions of this invention comprise defined individual (i.e. separate) components that may or may not remain the same chemically before and after mixing.

[0034] The present invention is illustrated by, but in no way limited to, the following examples.

Examples

[0035] Marine diesel cylinder lubricant compositions were prepared having TBNs of either 40 or 70. The lubricant compositions comprised: an overbased complex calcium detergent including phenate and sulphonate surfactants; a calcium phenate having a base number of 250; a borated dispersant; and an anti-wear agent.

[0036] The lubricant compositions were subjected to the Bolnes Test using a Bolnes crosshead engine (a single cylinder 2-stroke engine, the Bolnes 3DNL), calibrated and stabilized, operating on a fuel including about 3.5% sulphur. The Bolnes engine speed was 500 rpm with a lubricant feed rate of 1.00 g/kwh. Each lubricant composition was tested for 96 hours. The test conditions were designed to create corrosive wear of the cylinder liner over this time. Wear was

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measured in microns in specific calibrated places on the cylinder liner. The average recorded wear is reported below. The lower the recorded result, the less wear of the cylinder liner.

	Comparative Example 1	Example 2	Example 3	Example 4	Example 5
Detergent including at least two surfactants	15.24	12.10	10.80		
Detergent including at least two surfactants				14.30	7.15
250 TBN Calcium Phenate Detergent	3.34	8.00	10.00	8.02	6.00
Borated Dispersant	3.05	3.00			
Borated Dispersant			3.00	2.67	2.00
Antiwear Agent	0.28	1.00	0.50	0.67	0.50
Antioxidant			0.50		
Base oils	78.09	75.90	75.20	74.34	84.35
Base Number (ASTM D 2896-01)	70	70	70	70	40
Boron (ppm)	107	105	390	347	260
Zinc (ppm)	216	770	385	516	385
Bolnes Test					
Liner Wear, average	19	10	11	12	12

[0037] The above table clearly shows that less wear is produced with marine diesel cylinder lubricants including 385 ppm or more of zinc, when the detergent is prepared from at least two surfactants. It is particularly surprising that example 5, which has a TBN of 40, produces less wear with the high sulphur fuel than comparative example 1 which has a TBN of 70.

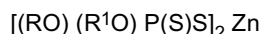
Claims

1. A marine diesel cylinder lubricant composition having a total base number, as determined according to ASTM D2896, of at least 35 and comprising:
 - at least 40 wt% of an oil of lubricating viscosity,
 - at least one detergent prepared from at least two surfactants, phenate and sulphonate surfactants,
 - at least one boron-containing dispersant providing at least 100 ppm of boron, and
 - at least one zinc-containing antiwear additive, preferably a zinc dihydrocarbyl dithiophosphate, providing more than 230 ppm, preferably at least 250 ppm, of zinc.
2. The marine diesel cylinder lubricant composition as claimed in claim 1. wherein the detergent includes at least 5 mass% of phenate and at least 5 mass% of sulphonate, based on the total amount of the detergent.
3. The marine diesel cylinder lubricant composition as claimed in claims 1 or 2, wherein the detergent further includes a salicylate surfactant, preferably at least 5 mass% of salicylate, based on the total amount of the detergent.
4. The marine diesel cylinder lubricant composition as claimed in any one of the preceding claims, wherein the lubricant has a base number of at least 40, preferably at least 60.
5. The marine diesel cylinder lubricant composition as claimed in any one of the preceding claims, wherein the dispersant

provides at least 150 ppm, preferably at least 200 ppm, of boron, based on the total amount of the marine diesel cylinder lubricant composition.

6. The marine diesel cylinder lubricant composition as claimed in any one of the preceding claims, wherein the antiwear additive provides at least 275 ppm, preferably at least 300 ppm, more preferably at least 325 ppm, even more preferably at least 350 ppm, even more preferably at least 375 ppm and most preferably at least 385 ppm, of zinc.

7. The marine diesel cylinder lubricant composition as claimed in any one of the preceding claims, wherein the antiwear additive is an oil-soluble salt of a dihydrocarbyl dithiophosphoric acid represented by the following formula;



where R and R¹ may be the same or different hydrocarbyl radicals containing from 1 to 18, preferably 2 to 12, carbon atoms and including radicals such as alkyl, alkenyl, aryl, arylalkyl, alkaryl and cycloaliphatic radicals.

8. The marine diesel cylinder lubricant composition as claimed in any one of the preceding claims, further including an aminic or phenolic antioxidant.

9. A method of operating a marine diesel engine, preferably using a fuel having a sulphur content of at least 3.0%, preferably at least 3.5%, the method including the step of using the marine diesel cylinder lubricant composition claimed in any one of claims 1-8 to lubricate the engine,

10. Use of the marine diesel cylinder lubricant composition as claimed in any one of claims, preferably with a fuel having a sulphur level of at least 3.0%, preferably at least 3.5%, to reduce wear in a marine diesel engine.

Patentansprüche

1. Schmiermittelzusammensetzung für einen Schiffsdieselmotor, die eine Gesamtbasenzahl von mindestens 35 aufweist, wie gemäß ASTM D2896 gemessen, und umfasst:

- mindestens 40 Gew.-% Öl mit Schmierviskosität,
- mindestens ein Detergens, das aus mindestens zwei Tensiden, Phenolat- und Sulfonat-Tensiden, hergestellt ist,
- mindestens ein borhaltiges Dispergiermittel, das mindestens 100 ppm Bor bereitstellt, und
- mindestens ein zinkhaltiges Antiverschleißadditiv, vorzugsweise ein Zinkdikohlenwasserstoffdithiophosphat, das mehr als 230 ppm, vorzugsweise mindestens 250 ppm Zink bereitstellt.

2. Schmiermittelzusammensetzung für einen Schiffsdieselmotor nach Anspruch 1, bei der das Detergens mindestens 5 Masse-% Phenolat und mindestens 5 Masse-% Sulfonat enthält, bezogen auf die Gesamtmenge des Detergens.

3. Schmiermittelzusammensetzung für einen Schiffsdieselmotor nach den Ansprüchen 1 oder 2, bei der das Detergens ferner Salicylat-Tensid, vorzugsweise mindestens 5 Masse-% Salicylat umfasst, bezogen auf die Gesamtmenge des Detergens.

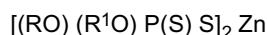
4. Schmiermittelzusammensetzung für einen Schiffsdieselmotor nach einem der vorhergehenden Ansprüche, bei der das Schmiermittel eine Basenzahl von mindestens 40, vorzugsweise mindestens 60 aufweist.

5. Schmiermittelzusammensetzung für einen Schiffsdieselmotor nach einem der vorhergehenden Ansprüche, bei der das Dispergiermittel mindestens 150 ppm, vorzugsweise mindestens 200 ppm Bor bereitstellt, bezogen auf die Gesamtmenge der Schmiermittelzusammensetzung für einen Schiffsdieselmotor.

6. Schmiermittelzusammensetzung für einen Schiffsdieselmotor nach einem der vorhergehenden Ansprüche, bei der das Antiverschleißadditiv mindestens 275 ppm, vorzugsweise mindestens 300 ppm, stärker bevorzugt mindestens 325 ppm, noch stärker bevorzugt mindestens 350 ppm, noch stärker bevorzugt mindestens 375 ppm und am meisten bevorzugt mindestens 385 ppm Zink bereitstellt.

7. Schmiermittelzusammensetzung für einen Schiffsdieselmotor nach einem der vorhergehenden Ansprüche, bei

der das Antiverschleißadditiv ein öllösliches Salz einer Dikohlenwasserstoffdithiophosphorsäure ist, das durch die folgende Formel wiedergegeben wird:

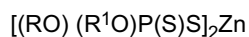


in der R und R¹ gleiche oder unterschiedliche Kohlenwasserstoffreste sein können, die 1 bis 18, vorzugsweise 2 bis 12 Kohlenstoffatome enthalten und Reste wie Alkyl, Alkenyl, Aryl, Arylalkyl, Alkylaryl und cycloaliphatische Reste einschließen.

8. Schmiermittelzusammensetzung für einen Schiffsdieselmotor nach einem der vorhergehenden Ansprüche, die ferner aminisches oder phenolisches Antioxidans einschließt.
9. Verfahren zum Betreiben eines Schiffsdieselmotors, bei dem vorzugsweise ein Brennstoff, der einen Schwefelgehalt von mindestens 3,0 %, vorzugsweise mindestens 3,5 % aufweist, verwendet wird, welches Verfahren den Schritt einschließt, bei dem eine Schmiermittelzusammensetzung für einen Schiffsdieselmotor gemäß einem der Ansprüche 1 bis 8 verwendet wird, um den Motor zu schmieren.
10. Verwendung der Schmiermittelzusammensetzung für einen Schiffsdieselmotor gemäß einem der Ansprüche, vorzugsweise mit einem Kraftstoff, der einen Schwefelgehalt von mindestens 3,0 %, vorzugsweise mindestens 3,5 % aufweist, um den Verschleiß in einem Schiffsdieselmotor zu reduzieren.

Revendications

1. Composition de lubrifiant de cylindres de moteur diesel marin ayant un indice de basicité total, tel que déterminé suivant la norme ASTM D2896, d'au moins 35 et comprenant :
 - au moins 40 % en poids d'une huile de viscosité propre à la lubrification,
 - au moins un détergent préparé à partir d'au moins deux agents tensioactifs, un agent tensioactif du type phénate et un agent tension actif du type sulfonate,
 - au moins un dispersant contenant du bore fournissant au moins 100 ppm de bore, et
 - au moins un additif anti-usure contenant du zinc, de préférence un dihydrocarbyldithiophosphate de zinc, fournissant plus de 230 ppm, de préférence au moins 250 ppm, de zinc.
2. Composition de lubrifiant de cylindres de moteur diesel marin suivant la revendication 1, dans laquelle le détergent comprend au moins 5 % en masse de phénate et au moins 5 % en masse de sulfonate, sur la base de la quantité totale de détergent.
3. Composition de lubrifiant de cylindres de moteur diesel marin suivant la revendication 1 ou 2, dans laquelle le détergent comprend en outre un agent tensioactif du type salicylate, de préférence au moins 5 % en masse de salicylate, sur la base de la quantité totale de détergent.
4. Composition de lubrifiant de cylindres de moteur diesel marin suivant l'une quelconque des revendications précédentes, dans laquelle le lubrifiant a un indice de basicité d'au moins 40, de préférence d'au moins 60.
5. Composition de lubrifiant de cylindres de moteur diesel marin suivant l'une quelconque des revendications précédentes, dans laquelle le dispersant fournit au moins 150 ppm, de préférence au moins 200 ppm, de bore, sur la base de la quantité totale de la composition de lubrifiant de cylindres de moteur diesel marin.
6. Composition de lubrifiant de cylindres de moteur diesel marin suivant l'une quelconque des revendications précédentes, dans laquelle l'additif anti-usure fournit au moins 275 ppm, avantageusement au moins 300 ppm, plus avantageusement au moins 325 ppm, encore plus avantageusement au moins 350 ppm, encore plus avantageusement au moins 375 ppm et de préférence au moins 385 ppm, de zinc.
7. Composition de lubrifiant de cylindres de moteur diesel marin suivant l'une quelconque des revendications précédentes, dans laquelle l'additif anti-usure est un sel soluble dans l'huile d'un acide dihydrocarbyl-dithiophosphorique représenté par la formule suivante :



dans laquelle R et R¹ peuvent représenter des radicaux hydrocarbyle identiques ou différents contenant 1 à 18, de préférence 2 à 12, atomes de carbone et comprenant des radicaux tels que des radicaux alkyle, alcényle, aryle, arylalkyle, alkaryle et cycloaliphatiques.

8. Composition de lubrifiant de cylindres de moteur diesel marin suivant l'une quelconque des revendications précédentes, comprenant en outre un antioxydant aminique ou phénolique.
9. Procédé pour faire fonctionner un moteur diesel marin, utilisant de préférence un carburant ayant une teneur en soufre d'au moins 3,0 %, de préférence d'au moins 3,5 %, le procédé comprenant l'étape d'utilisation d'une composition de lubrifiant de cylindres de moteur diesel marin suivant l'une quelconque des revendications 1 à 8 pour lubrifier le moteur.
10. Utilisation de la composition de lubrifiant de cylindres de moteur diesel marin suivant l'une quelconque des revendications précédentes, de préférence avec un carburant ayant une teneur en soufre d'au moins 3,0 %, de préférence d'au moins 3,5%, pour réduire l'usure dans un moteur diesel marin.

REFERENCES CITED IN THE DESCRIPTION

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