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(54) **METHOD OF RECONDITIONING A COMPRESSION-IGNITION ENGINE SYSTEM**

(57) The present disclosure relates to the field of compression-ignition engines and their operation. It is herein provided a method of reconditioning a compression-ignition engine wrongfully filled with a petrol-like fuel and a container comprising a mixture for reconditioning of the same engine.

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Description

Field of invention

[0001] The present invention relates to the field of compression-ignition engines and their operation. A method of reconditioning a compression-ignition engine wrongly filled with a petrol-like fuel is provided herein and furthermore a container comprising a mixture for reconditioning of the same engine.

Background of invention

[0002] If a diesel car gets gasoline into the tank, the gasoline has to be removed and the tank and fuel system has to be cleaned before the car can be used in order to avoid the risk of damage of the engine. This is an expensive and time consuming operation.

This happens frequently when diesel cars are misfuelled with gasoline at gas stations.

[0003] The problem with gasoline in a diesel car is caused by the different properties of the two fuels. The combustion properties of gasoline do not work for a diesel engine and the motor will not run properly. A study by Wei and Spikes (1999) indicates that the low lubricity of gasoline is not dependent on the chemical structure of its components, but rather on the viscosity.

[0004] Some documents show that a fuel can be processed so to improve its characteristics and so that it is better utilized by an engine. For example, US 2013/0298452 A1 discusses the problem of low lubricity of diesel and petrol fuels and how it can be damaging for engines. The same patent application discloses a composition that improves the lubricity of diesel or gasoline and so improves the mileage of a diesel or gasoline vehicle, respectively, that employs the treated fuel. Similarly, WO2005/035694 discloses additives for low-quality transportation fuels, where the fuels have detrimental effects on an engine when used as such. The specific compositions are added to either low-quality gasoline or to low-quality diesel, so to improve their characteristics, such as the octane number of gasoline and the lubricity of diesel. US Patent No. 5,891,203 shows how the lubricity of diesel fuels is improved by addition of diethanolamine derivatives and biodiesel. However, these documents treat a fuel before its addition to the tank of a vehicle and do not deal with the problem of a vehicle filled with a wrong fuel.

[0005] In particular, if a diesel vehicle is filled with gasoline, the low lubricity of gasoline will cause problems to the high pressure fuel pumps and fuel injectors in the diesel engine, which requires lubrication from the fuel. If the lubrication properties are too low the pump will break down and fail quickly. The consequence is that the tank has to be emptied and the damaged parts substituted. This means that the problem can only be solved by an expert and by spending considerable amount of time and money.

Summary of invention

[0006] Currently, reconditioning of a compression-ignition engine that has been wrongly filled with a petrol-like fuel requires emptying of the fuel supply reservoir and substitution of important parts of the engine system. Thus, there is a need for a solution that does not require specific technical skills, considerable amount of time and money.

[0007] The present invention provides a simple method for reconditioning of a compression-ignition engine that has been wrongly filled with a petrol-like fuel involving addition of a homogenous mixture of a lubricant and a cetane number improver to the petrol-like fuel. Mixing a petrol-like fuel with a lubricant and a cetane number improver renders the petrol-like fuel suitable for use in a compression-ignition engine.

[0008] However, addition of such compounds is challenging once the petrol-like fuel has been added to the fuel reservoir of an engine system. The main reason is that often only a small portion of the total volume of the tank is accessible and it is therefore difficult to mix the fuel already present in the tank with the additives by physical means. It is crucial to transform all of the fuel in tank to prevent serious damages and that can only be obtained by thoroughly mixing the lubricant and cetane number improver with the fuel to obtain a mixture in the fuel tank.

[0009] Surprisingly, the present invention discloses that if a homogenous mixture of lubricant and cetane number improver is added directly to a petrol-like fuel in a fuel supply reservoir, then said mixture will mix sufficiently with the petrol-like fuel in the reservoir even in the absence of any additional physical mixing. Thus, the invention allows adding a homogenous mixture of a lubricant and a cetane number improver to any fuel supply reservoir containing a petrol-like fuel. Thus, even if said reservoir only is accessible through a small opening, then it will be possible to obtain a mixture of petrol-like fuel, lubricant and cetane number improver, which is sufficiently mixed for use as fuel in a compression-ignition engine.

[0010] Thus, the present disclosure provides a method of reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel, said method comprising the steps of:

- providing a homogeneous mixture comprising 0.25-10% v/v of a lubricant and 90-99.75% v/v of a cetane number improver,
- adding said mixture to the fuel supply reservoir.

[0011] The present disclosure also provides a closed container comprising:

- a mixture consisting of a lubricant, 0.25-10% v/v, a

- cetane number improver, 90-99.75% v/v, and an inert gas.

[0012] The present disclosure also provides use of a homogeneous mixture comprising 0.25-10% v/v of a lubricant and 90-99.75% v/v of a cetane number improver for reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel.

Description of the drawings

[0013]

Figure 1. Engine operation with gasoline supplemented with a mixture of 5% 2-EHN and 160 ppm of R655 lubricant from Infineum at 3 bar IMEP. The plot shows the four cylinder pressure traces, the heat release and the fuel injection command.

Figure 2. Engine operation with gasoline supplemented with a mixture of 5% 2-EHN and 160 ppm of R655 lubricant from Infineum at 6 bar IMEP. The plot shows the four cylinder pressure traces, the heat release and the fuel injection command.

Figure 3: Non-homogeneous mixture just after adding 20 ml of pre-mixed fuel additive to gasoline (A). Homogeneous mixture of gasoline and fuel additive 2 minutes after pouring (B).

Detailed description of the invention

Definition

[0014] The term "cetane number" as used herein refers to a measure of the propensity of a fuel to auto-ignite due to compression. The higher the cetane number the less compression is required for auto-ignition. The higher the cetane number, the faster will the fuel combust in a compression-ignition engine. The cetane number is an inverse function of a fuel's ignition delay, and the time period between the start of injection and the first identifiable pressure increase during combustion of the fuel. In a particular diesel engine, higher cetane fuels will have shorter ignition delay periods than lower cetane fuels. The cetane number of a fuel composition may be determined in known manner, for instance using the Standard test procedure ASTM D613 (ISO 5165, IP 41) which provides a so-called "measured" cetane number obtained under engine running conditions. More preferably the cetane number may be determined using the more recent and accurate "ignition quality test (IQT)" (ASTM D6890, IP 498/03), which provides a "derived" cetane number based on the time delay between injection and combustion of a fuel sample introduced into a constant volume

combustion chamber. This relatively rapid technique can be used on laboratory scale (ca. 100ml) samples of a range of different fuels. Alternatively, cetane number may be measured by near infrared spectroscopy (NIR), as for example described in US-A-5349188. This method may be preferred in a refinery environment as it can be less cumbersome than for instance ASTM D613. NIR measurements make use of a correlation between the measured spectrum and the actual cetane number of the sample. An underlying model is prepared by correlating the known cetane numbers of a variety of fuel samples with their near infrared spectral data.

[0015] The term "cetane number improver" as used herein refers to a compound or a mixture of compounds that when added to a fuel results in an increase of the cetane number of that fuel. Cetane number improvers may be also referred to as ignition accelerators, ignition improver or combustion improvers. A compound used as cetane number improver, when added to a fuel composition, causes an increase in cetane number, such as an increase in cetane number that is not linearly proportional to the amount of cetane number improver added. The cetane number may be determined by any useful test, however, in order to determine whether a particular compound or mixture of compounds are cetane number improver, then in general the same test should be applied to determine the cetane number before and after addition of the compound(s). Compounds used as cetane number improvers comprise hydrocarbons comprising a straight chain of at least 7 carbon atoms, organic nitrates and organic peroxides.

[0016] The term "compression-ignition engine" as used herein refers to an internal combustion engine in which the ignition of the fuel into the combustion chamber is initiated by the high temperature achieved by a compressed gas.

[0017] The term "diesel" as used herein refers to a fuel having the following characteristics at standard ambient pressure (101 kPa):

- cetane number between 38 and 60;
- vapour pressure between 1 and 10 kPa at 20 °C;
- viscosity (measured at 37.8°C) between 1.2 mm²/s and 3.6 mm²/s;
- initial boiling point (IBP) between 125°C and 225°C;
- final boiling point (FBP) between 260°C and 385°C;
- it comprises hydrocarbons consisting of C₁₆ to C₂₂ carbon atoms;
- it comprises at least 70% and at max 95% v/v of saturated hydrocarbons;
- it comprises at least 3% at max 35% v/v of aromatic hydrocarbons.

Diesel fuel can originate from fractional distillation of crude oil or petroleum at temperatures between 200 and 300 °C, but also from biomass-derived oil, biomass and gaseous hydrocarbons including natural gas.

[0018] The term "diesel-like" as used herein refers to

a fuel that, in a compression-ignition engine, can ignite when injected in a chamber containing highly compressed gas. A diesel-like fuel preferably has a cetane number in the range of 38 to 60.

[0019] The term "fuel supply reservoir" as used herein refers to a chamber connected to a compression-ignition engine that can be filled with fuel and allow storage of the fuel in the system operated by such engine. In particular, a fuel supply reservoir may be a tank.

[0020] The term "lubricant" as used herein refers to a compound or a mixture that reduce friction between surfaces in mutual contact. A lubricant, when added to a fuel, enhances the fuel lubricating action and so helps prevent wear damage in the fuel system and in the engine. Lubricants can be organic molecules that provide a lubricating film between metal surfaces. Typically, lubricants are compounds characterized by having a polar functional group attached to a lipophilic group, for example fatty acids. A "lipophilic group" as used herein refers to a chemical group that tends to dissolve in fats, oil, non-polar solvents. Lipophilic groups or compounds are characterized by having large octanol/water partition coefficient ($\log_{10}P$), such as a $\log_{10}P$ in the range of 3 and 10. The polar functional groups can for example be carboxylic acids or amides.

[0021] The term "motor fuel" is a general term that incorporates all fuels used to provide power to an engine.

[0022] The term "petrol", also referred to as "gasoline", as used herein refers to a fuel produced by fractional distillation of crude oil or petroleum at temperatures below 150°C. The term petrol refers to a fuel having the following characteristics at standard ambient pressure 101 kPa:

- octane rating of 91-112 Research Octane Number (RON), such as 83-105 Anti-Knock Index (AKI)
- vapour pressure of diesel is between 48 and 100 kPa at 20 °C;
- viscosity (measured at 37.8°C) between 0.45 mm²/s and 0.5 mm²/s;
- initial boiling point (IBP) between 28°C and 40°C;
- final boiling point (FBP) between 175°C and 201 °C;
- it comprises hydrocarbons consisting of C₅ to C₁₂ carbon atoms;
- it comprises at least 50% and at max 65% v/v of saturated hydrocarbons;
- it comprises at least 25% and at max 40% v/v of aromatic hydrocarbons.

[0023] The term "petrol-like" as used herein refers to a fuel suitable for operating an internal combustion engine with spark-ignition. Petrol-like fuel has preferably an octane number of 91-112 RON or 83-105 AKI.

[0024] The term "reconditioning" as used herein refers to the process of repairing a system by actively modifying the defective features. In particular, as used herein "reconditioning" means converting petrol fuel or a petrol-like fuel to a fuel useful for use in a compression-ignition en-

gine system.

Method of reconditioning a compression-ignition engine system

[0025] The present disclosure relates to a method of reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel. The method disclosed comprises the steps of providing a homogeneous mixture comprising in the range of 0.1 to 10% of a lubricant and in the range of 90 to 99.9% of a cetane number improver and adding said mixture to the fuel supply reservoir. For example, said mixture may contain 0.25-10% of a lubricant and 90-99.75% of a cetane number improver. There is no need of stirring the mixture once it has been added to the fuel supply reservoir. Thus, in one embodiment the method of the invention does not comprise a step of active physical mixing beyond mixing achieved by normal operation of the engine. The cetane number improver and the lubricant may be any of the cetane number improvers and lubricants described in the sections below "Cetane number improver" and "Lubricant", respectively.

[0026] The petrol-like fuel in the fuel supply reservoir may be any kind of petrol-like fuel, Preferably, the petrol-like fuel in the fuel supply reservoir has initial boiling point between 28°C and 40°C and final boiling point between 177°C and 201°C.

[0027] In one embodiment the petrol-like fuel in the fuel supply reservoir comprises petrol. For example the petrol-like fuel in said reservoir may consist of petrol. The petrol fuel may in addition to petrol contain a minor part of another fuel, for example ethanol as alternative fuel, below 15% volume. It is preferred that the petrol-like fuel that is present in the fuel supply reservoir of the engine comprises at least 80% petrol, such as at least 85% petrol, such as at least 90% petrol, such as at least 95% petrol. The remainder of the petrol-like fuel may comprise or consists of another fuel, e.g. ethanol. Thus, the petrol-like fuel may also comprise ethanol, for example 5% ethanol, such as 10% ethanol, such as 15% ethanol.

[0028] Preferably, the compression-ignition engine system that needs reconditioning is part of a motor vehicle or of an electric generator, as described in the section below "Engine system".

[0029] Preferably, the fuel supply reservoir that is part of the compression-ignition engine system that needs reconditioning is a tank.

[0030] The method disclosed herein comprises adding a mixture of a lubricant and a cetane number improver to the petrol-like fuel in the fuel supply reservoir of the compression-ignition engine system that needs reconditioning, and that results in the petrol-like fuel being modified into a diesel-like fuel, such as into a motor fuel that can be ignited by a compression-ignition engine. It is generally preferred that the mixture of lubricant and cetane

number improver is a homogenous mixture, in particular, it is preferred that it is a homogenous mixture immediately prior to addition to the fuel supply reservoir. This may be achieved by thorough mixing the lubricant and the cetane number improver immediately prior to addition to the fuel supply reservoir. Thus, in one embodiment, the method of reconditioning a compression-ignition engine system may comprise the steps of:

- a. providing a mixture comprising in the range of 0.1 to 10% in volume of said lubricant and in the range of 90-99.9% in volume of said cetane number improver, for example 0.25-10% in volume of said lubricant and 90-99.75% in volume of said cetane number improver,
- b. mixing said mixture in order to obtain a homogenous mixture
- c. adding said homogenous mixture to the fuel supply reservoir.

[0031] In one embodiment, the mixture of lubricant and cetane number improver is stored in a closed container prior to use.

[0032] In some embodiments, the container comprising the mixture is shaken prior to addition of the mixture to the fuel supply reservoir. In particular, said container may be shaken in order to obtain a homogenous mixture. The mixture is then added to the fuel supply reservoir and the engine is turned on after at least 1 minute, preferably after at least 2 minutes, preferably after at least 3 minutes, preferably after at least 4 minutes, preferably after at least 5 minutes. Preferably, after adding the mixture to the fuel supply reservoir comprising a petrol-like fuel, no active mixing is applied to the fuel supply reservoir.

[0033] As described above, the present invention surprisingly discloses that if a homogenous mixture of lubricant and cetane number improver is added directly to a petrol-like fuel in a fuel supply reservoir, then said mixture will mix sufficiently with the petrol-like fuel in the reservoir even in the absence of any additional physical mixing. It is preferred that at the most 10 min., preferably at the most 7 min. more preferably at the most 5 min, such as at the most 3 min. after the homogenous lubricant and cetane improver mixture is added to the fuel supply reservoir, then the lubricant and cetane number improver are sufficiently mixed with said petrol-like fuel. Sufficient mixing may be determined in any useful manner. In one embodiment sufficient mixing is determined by adding a homogenous mixture of lubricant and cetane number improver to a petrol-like fuel (preferably in a ratio described herein elsewhere) without application of physical mixing or agitation, and determining turbidity. If the difference in turbidity compared to a fully mixed mixture of cetane number improver, lubricant and petrol-like fuel is reduced by at least 90% within 10 min. preferably within 7 min., more preferably within 5 min., such as within 3 min. after addition of said homogenous mixture, then sufficient mixing

is considered to have occurred. Turbidity may be determined using a turbidity tube or an optical turbidity sensor based on light scattering. A non-limiting example of a turbidity sensor is a nephelometer. It may be impractical to determine sufficient mixing in a fuel supply reservoir, and accordingly, sufficient mixing may be determined in a test system, e.g. as described herein below in Example 3 or 4. It is considered that mixing will have occurred in a fuel supply reservoir if mixing has occurred in a similar test system, for example if the test system uses the same lubricant, cetane number improver and petrol-like fuel in the same or similar ratios.

[0034] The lubricant concentration in the fuel supply reservoir, after addition of the mixture according to the disclosed method, is preferably in the range of 0.005 to 0.5% v/v, for example in the range of 0.010 to 0.5% v/v, such as in the range of 0.013 to 0.5% v/v. Preferably, the lubricant concentration may be in the range of 0.005 to 0.4% v/v, for example in the range of 0.01 to 0.4% v/v, for example 0.013 to 0.4% v/v, such as in the range of 0.005 to 0.3% v/v, for example in the range of 0.01 to 0.3% v/v, such as in the range of 0.013 to 0.3% v/v, such as in the range of 0.005 to 0.2% v/v, for example in the range of 0.01 to 0.2% v/v, such as in the range of 0.013 to 0.2% v/v, such as in the range of 0.005 to 0.1% v/v, for example in the range of 0.01 to 0.1% v/v, such as in the range of 0.013 to 0.1% v/v, such as in the range of 0.005 to 0.05% v/v, for example in the range of 0.01 to 0.05% v/v, such as in the range of 0.013 to 0.05% v/v. The lubricant concentration in the fuel supply reservoir, after addition of the mixture according to the disclosed method, is preferably in the range of 0.005 to 0.5%, such as in the range of 0.01 to 0.5%, for example in the range of 0.02 to 0.5% v/v, such as in the range of 0.05 to 0.5% v/v, such as in the range of 0.1 to 0.5% v/v, such as in the range of 0.2 to 0.5% v/v, such as in the range of 0.3 to 0.5% v/v, such as in the range of 0.4 to 0.5% v/v.

[0035] The concentration of the cetane number improver in the fuel supply reservoir, after addition of the mixture according to the disclosed method, may preferably be in the range of 0.45 to 10% v/v. Preferably, the concentration of the cetane number improver is in the range of 0.45 to 9% v/v, such as in the range of 0.45 to 8% v/v, such as in the range of 0.45 to 7% v/v, such as in the range of 0.45 to 6% v/v, such as in the range of 0.45 to 5% v/v, such as in the range of 0.45 to 4% v/v, such as in the range of 0.45 to 3% v/v, such as in the range of 0.45 to 2% v/v, such as in the range of 0.45 to 1% v/v. The concentration of the cetane number improver in the fuel supply reservoir, after addition of the mixture according to the disclosed method, is preferably in the range of 0.5 to 10% v/v, such as in the range of 1 to 10% v/v, such as in the range of 2 to 10% v/v such as in the range of 3 to 10% v/v such as in the range of 4 to 10% v/v, such as in the range of 5 to 10% v/v, such in the range of 6 to 10% v/v, such as in the range of 7 to 10% v/v, such as in the range of 8 to 10% v/v, such as in the range of 9 to 10% v/v. In particular, the concentration of

the cetane number improver in the fuel supply reservoir, after addition of the mixture according to the disclosed method, is preferably in the range of 2 to 10% v/v, such as in the range of 2 to 6% v/v.

[0036] Sometimes it may be impractical to determine the exact content of the petrol-like fuel in the fuel supply reservoir. Instead an approximate volume may be estimated, and this volume used for determining the amount of lubricant and cetane number improver to be added.

[0037] The method disclosed herein can change the characteristics of the petrol-like fuel contained in the fuel supply reservoir. Preferably, the method of the present disclosure results in the fuel contained in the fuel supply reservoir having a cetane number in the range of 38 to 65, such as in the range of 38 to 60, such as in the range of 38 to 55, such as in the range of 38 to 50, such as in the range of 38 to 45, such as in the range of 38 to 42 after addition of said mixture. Preferably, the method of the present disclosure results in the fuel contained in the fuel supply reservoir having a cetane number in the range of 42 to 65, such as in the range of 45 to 65, such as in the range of 50 to 65, such as in the range of 55 to 65, such as in the range of 60 to 65 after addition of said mixture. Preferably, the method of the present disclosure results in the fuel contained in the fuel supply reservoir having a lubricity that results in a wear scar diameter of lower than 460 μm .

[0038] The method of reconditioning a compression-ignition engine system disclosed herein results in a coefficient of variation of IMEP in a range of 3 to 10% at 1 bar IMEP (idle) and in a range of 1 to 10% at 6 bar IMEP. Preferably, the reconditioning results in the coefficient of variation of IMEP at 6 bar being lower than 10%, such as lower than 9%, such as lower than 8%, such as lower than 7% such as lower than 6%, such as lower than 5%, such as lower than 4%, such as lower than 3%, such as lower than 2%. More preferably, the reconditioning results in the coefficient of variation of IMEP at 6 bar being equal or lower than 5%. The reconditioning results in the coefficient of variation of IMEP at 1 bar IMEP being lower than 10%, such as lower than 9%, such as lower than 8%, such as lower than 7% such as lower than 6%.

[0039] The method disclosed herein can be performed at any suitable temperature. Thus, the method may for example be performed at any temperature above -10°C , for example at a temperature in the range of -10°C to $+50^{\circ}\text{C}$. Preferably, the temperature at which the method is performed is comprised between -10°C and $+40^{\circ}\text{C}$, such as between -10°C and $+30^{\circ}\text{C}$, such as between -10°C and $+25^{\circ}\text{C}$, such as between -10°C and $+20^{\circ}\text{C}$, such as between -10°C and $+15^{\circ}\text{C}$, such as between -10°C and $+10^{\circ}\text{C}$, such as between -10°C and $+5^{\circ}\text{C}$, such as between -10°C and $+5^{\circ}\text{C}$, such as between -10°C and 0°C , such as between -10°C and -5°C . Preferably, the method can be performed at any temperature that occurs outdoors at any time of the year and at any latitude.

Engine system

[0040] The present disclosure relates to a method of reconditioning an engine system, the system characterized by comprising a compression-ignition engine and a fuel reservoir filled with a petrol-like fuel. The so described engine system cannot run properly when filled with a petrol-like fuel and the method of reconditioning the system, as disclosed herein, allows the engine system to run properly again.

[0041] The compression-ignition engine may be any compression-ignition engine. The engine system can be part of a motor vehicle. Examples of motor vehicles comprising a compression-ignition engine system are cars, buses, motorcycles, off-road vehicles, light trucks, regular trucks, ships, boats, hovercraft, submarines, heavy-duty vehicles and aircrafts. Thus, the method of the invention may comprise the step of adding a homogenous mixture of a lubricant and a cetane number improver to the tank of a motor vehicle, for example to the tank of a car. In the event that a car driven by a compression-ignition engine (e.g. a diesel car) is misfuelled with petrol or a petrol-like fuel, then addition of a homogenous mixture of lubricant and cetane number improver directly into the tank of said car according to the methods of the invention, will allow the car to run normally.

[0042] The compression-ignition engine system that needs reconditioning can also be part of an electric generator, such as small portable electric generators.

[0043] The engine system comprises a fuel reservoir as described in detailed in the section below "Fuel supply reservoir".

Cetane number improver

[0044] The present disclosure relates to a method of reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel. The method disclosed, described in details in the section above "Method of reconditioning a compression-ignition engine system", comprises addition of a homogeneous mixture comprising a lubricant, described below in the section "Lubricant", and a cetane number improver to the fuel supply reservoir.

[0045] As described in the definition above, the cetane number improver may be any hydrocarbon comprising a straight chain of at least 7 carbon atoms, or any organic nitrate or any organic peroxide. For example, the cetane number improver may be any fuel having cetane number higher than the cetane number of the fuel already present in the engine system to be reconditioned. Preferably, the cetane number improver is selected from a group consisting of alkyl nitrates, organic peroxides and fatty alcohol nitrate esters. In one embodiment, the cetane number improver is a compound selected from the group consisting of 2-ethylhexyl nitrate (2-EHN), di-tertiary-butyl per-

oxide (DTBP or DTB) and fatty alcohol nitrate ester (FANE). In one embodiment the cetane number improver comprises or consists of 2-EHN.

[0046] In one embodiment of the present disclosure, the cetane number improver comprised in the homogeneous mixture is 2-EHN.

Lubricant

[0047] The present disclosure relates to a method of reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel. The method disclosed, described in details in the section above "Method of reconditioning a compression-ignition engine system", comprises addition of a homogeneous mixture comprising a lubricant and a cetane number improver, described above in the section "Cetane number improver", to the fuel supply reservoir.

[0048] The lubricity of a fuel is usually measured by means of specific empirical methods well known to experts in the field, such as the indication of the so-called lubricity according to the high frequency reciprocating rig (HFRR) method (regulation CEC-F-06-A-96), which measures the wear scar diameter.

[0049] The lubricant used with the present disclosure preferably has melting temperature above the temperature at which the disclosed method is performed. Thus, the lubricant preferably has a melting temperature above -10°C.

[0050] Lubricants can be synthetic, derived from crude oil or biological. Lubricants that derive from crude oil are also called mineral oil and they can be paraffinic hydrocarbons, naphthenic hydrocarbons and aromatic hydrocarbons, where said hydrocarbons have been modified with addition of at least one polar group, such as a carboxylic acid, an ester, or an amide. In one embodiment the lubricant comprises a compound selected from the group consisting of fatty acids and esters thereof. More preferably the lubricant may comprise or consists of a fatty acid. Lubricants that derive from biological sources may be triglyceride esters and can have a vegetable origin like canola oil, castor oil, palm oil, sunflower seed oil, rapeseed oil and tall oil. They can also derive from animals, for example lanolin. Lubricants can also be of synthetic origin.

[0051] Thus, for example the lubricant to be used with the invention may be selected from the group consisting of AO series products, AO 22™, AO 24™, AO 29™, AO 30™, AO 3™, AO 32™, AO 36™, AO 36D™, AO 37™, AO 37D™, DCI series products, DCI 4A™, DCI 6A™, DCI 11™, DCI 28™, and DCI 30™, HITEC 4140A™, 4142™, 4898™, 580™, ONDEO-NALCO 5403™, OLI 5015™, OLI 5000 series products, OLI 9000 series products, R655 from Infineum, oils, and polyalphaolefins.

[0052] In some embodiments, tally-oil based lubricants

are used. In a preferred embodiment, the tally-oil based lubricant R655 from Infineum is used.

Container

[0053] The methods of the present disclosure relate to use of a mixture of a lubricant and a cetane number improver. Prior to addition of said mixture to a fuel supply reservoir according to the methods of the invention, then said mixture may be stored in a closed container. Thus, the invention also relates to a closed container comprising a mixture comprising 0.25-10% v/v of a lubricant, 90-99.75% v/v of a cetane number improver. In addition to said mixture, the container may also comprise an inert gas. Preferably, the container only comprises said mixture and an inert gas, but no other compounds. The lubricant and the cetane number improver are described in detail in the above sections "Lubricant" and "Cetane number improver".

[0054] The mixture in the container is prepared by blending lubricant and cetane number improver, in the right amounts as described below. An inert gas may be added into the container to avoid oxidation of the components of the mixture. In one embodiment, the inert gas is nitrogen.

[0055] The concentration of the lubricant in the mixture can vary within a certain interval. The concentration of the lubricant in the mixture may be in the range of 0.1 to 9% v/v, for example in the range of 0.25-9% v/v, such as in the range of 0.1 to 8% v/v, for example in the range of 0.25-8% v/v, such as in the range of 0.1 to 7% v/v, for example in the range of 0.25-7% v/v, such as in the range of 0.1 to 5% v/v, for example in the range of 0.25-5% v/v such as in the range of 0.1 to 4% v/v, for example in the range of 0.25-4% v/v, such as in the range of 0.1 to 3% v/v, for example in the range of 0.25-3% v/v, such as in the range of 0.1 to 2% v/v, for example in the range of 0.25-2% v/v, such as in the range of 0.1 to 1.5% v/v, for example in the range of 0.25-1.5% v/v, such as in the range of 0.1 to 1.2% v/v, for example in the range of 0.25-1.2% v/v, such as in the range of 0.1 to 1% v/v, for example in the range of 0.25-1% v/v, such as in the range of 0.1 to 0.6% v/v, for example in the range of 0.25-0.6% v/v, such as in the range of 0.1 to 0.5% v/v, for example in the range of 0.25-0.5% v/v. The concentration of the lubricant in the mixture may be in the range of 0.3-10% v/v, such as in the range of 0.4-10% v/v, such as in the range of 0.5-10% v/v, such as in the range of 0.6-10% v/v, such as in the range of 0.7-10% v/v, such as in the range of 0.8-10% v/v, such as in the range of 0.9-10% v/v, such as in the range of 1-10% v/v, such as in the range of 2-10% v/v, such as in the range of 3-10% v/v, such as in the range of 4-10% v/v, such as in the range of 5-10% v/v, such as in the range of 6-10% v/v, such as in the range of 7-10% v/v, such as in the range of 8-10% v/v, such as in the range of 9-10% v/v.

[0056] The concentration of the cetane number improver in the mixture can also vary within a certain inter-

val. Accordingly, the concentration of the cetane number improver in the mixture may be in the range of 90 to 99.9% v/v, for example in the range of 90-99.5% v/v, such as in the range of 90-99.3% v/v, such as in the range of 90-99.1% v/v, such as in the range of 90-98.9% v/v, such as in the range of 90-98.7% v/v, such as in the range of 90-98.5% v/v, such as in the range of 90-98.3% v/v, such as in the range of 90-98.1% v/v, such as in the range of 90-97.9% v/v, such as in the range of 90-97.5% v/v, such as in the range of 90-97.3% v/v, such as in the range of 90-97.1% v/v, such as in the range of 90-96.9% v/v, such as in the range of 90-96.7% v/v, such as in the range of 90-96.5% v/v, such as in the range of 90-96.3% v/v, such as in the range of 90-96.1% v/v, such as in the range of 90-95.9% v/v, such as in the range of 90-95.7% v/v, such as in the range of 90-95.5% v/v, such as in the range of 90-95.3% v/v, such as in the range of 90-95.1% v/v, such as in the range of 90-94.9% v/v, such as in the range of 90-94.7% v/v, such as in the range of 90-94.5% v/v, such as in the range of 90-94.3% v/v, such as in the range of 90-94.1% v/v, such as in the range of 90-93.9% v/v, such as in the range of 90-93.7% v/v, such as in the range of 90-93.5% v/v, such as in the range of 90-93.3% v/v, such as in the range of 90-93.1% v/v, such as in the range of 90-92.9% v/v, such as in the range of 90-92.7% v/v, such as in the range of 90-92.5% v/v, such as in the range of 90-92.3% v/v, such as in the range of 90-92.1% v/v, such as in the range of 90-91.9% v/v, such as in the range of 90-91.7% v/v, such as in the range of 90-91.5% v/v, such as in the range of 90-91.3% v/v, such as in the range of 90-91.1% v/v, such as in the range of 90-90.9% v/v, such as in the range of 90-90.7% v/v, such as in the range of 90-90.5% v/v. The concentration of the cetane improver in the mixture in the container is in the range of 90.5-99.5% v/v, such as in the range of 91-99.5% v/v, such as in the range of 91 to 99.9% v/v, for example in the range of 91.5-99.5% v/v, such as in the range of 92 to 99.9% v/v, for example in the range of 92-99.5% v/v, such as in the range of 92.5-99.5% v/v, such as in the range of 92.5 to 99.9% v/v, for example in the range of 93 to 99.9% v/v, for example in the range of 93-99.5% v/v, such as in the range of 93.5 to 99.9% v/v, for example in the range of 93.5-99.5% v/v, such as in the range of 94 to 99.9% v/v, for example in the range of 94-99.5% v/v, such as in the range of 94.5 to 99.9% v/v, for example in the range of 94.5-99.5% v/v, such as in the range of 95 to 99.9% v/v, for example in the range of 95-99.5% v/v, such as in the range of 95.5 to 99.9% v/v, for example in the range of 95.5-99.5% v/v, such as in the range of 96 to 99.9% v/v, for example in the range of 96-99.5% v/v, such as in the range of 96.5 to 99.9% v/v, for example in the range of 96.5-99.5% v/v, such as in the range of 97 to 99.9% v/v, for example in the range of 97-99.5% v/v, such as in the range of 97.5 to 99.9% v/v, for example in the range of 97.5-99.5% v/v, such as in the range of 98 to 99.9% v/v, for example in the range of 98-99.5% v/v, such as in the range of 98.5 to 99.9% v/v, for example in the range of 98.5-99.5% v/v, such as in the range of

99 to 99.9% v/v, for example in the range of 99-99.5% v/v.

[0057] The container comprising the described mixture may be shaken so that the components are blended and a homogeneous mixture is obtained. The container may have a shape that promotes mixing. In some embodiments, the inner surface of the container is not smooth, for example it may have one or more indents and thus promotes mixing. In addition, the container comprises opening means, which allow opening and closing the container in a controllable manner, for example a lid.

[0058] In one embodiment of the present disclosure, the inert gas present in the container is nitrogen.

[0059] The container disclosed herein has capacity of at least 0.5 L and at most 25 L. Preferably, the capacity of the container is in the range of 0.5-20 L, such as 0.5-15 L, such as 0.5-10 L, such as 0.5-5 L, such as 0.5-1 L. The capacity of the container is of 1-25 L, such as 5-25 L, such as 10-25 L, such as 15-25 L, such as 20-25 L. In one embodiment, the container has a suitable size for use for reconditioning the engine of a car. In some embodiments the container comprises a mixture having volume in the range of 1 to 10L, which is suitable for reconditioning the engine of a car comprising a tank having a total capacity in the range of 40 to 60L. The container is preferably made of a non-transparent material. Materials and methods suitable for production of such a container are known and a person skilled in the art can easily choose a suitable container.

Fuel supply reservoir

[0060] The fuel supply reservoir is connected to the compression-ignition engine system and comprises an inlet, used to enter fuel into the reservoir itself, and an outlet through which the fuel reaches the engine. The fuel may move from the reservoir to the engine via one or more pumps.

[0061] The volume of the fuel supply reservoir depends on where the engine system is placed. In one embodiment, the fuel supply reservoir is a fuel tank. The fuel supply reservoir has a volume of at least 10 L, such as at least 20 L, such as at least 30 L, such as at least 40 L, such as at least 50 L. When the compression-ignition engine is used for operating a car, the fuel supply reservoir will typically be a tank with a volume of in the range of 30 to 200 L. The fuel supply reservoir can have larger volume, for example, a fuel supply reservoir situated in an aircraft can have a capacity as high as 100.000 L.

[0062] The inlet and outlet channels can have various shapes, preferably they are cylindrical. The dimensions of both the inlet and the outlet channel may be significantly smaller than the dimension of the fuel supply reservoir and the volume of fuel that can be contained in the inner and outer channels is significantly smaller, i.e. at least 1/25, such as at least 1/50, such as at least 1/100 than the volume of the fuel supply reservoir. The inlet and outlet channels can typically be closed and opened according to the operation of the engine system.

[0063] The fuel supply reservoir can be made of various materials from plastic to metal according to what is known in the art.

Items

[0064] The invention may further be defined by the following items:

1. A method of reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel, said method comprising the steps of:
 - a. providing a homogeneous mixture comprising 0.25-10% v/v of a lubricant and 90-99.75% v/v of a cetane number improver,
 - b. adding said mixture to the fuel supply reservoir.
2. A method of reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel, said method comprising the steps of:
 - a. providing a homogeneous mixture comprising 0.1-10% v/v of a lubricant and 90-99.9% v/v of a cetane number improver,
 - b. adding said mixture to the fuel supply reservoir.
3. The method according to any one of the preceding items, wherein the petrol-like fuel has initial boiling point in the range of 28°C to 40°C and final boiling point in the range of 177°C to 201°C.
4. The method according to any one of the preceding items, wherein said petrol-like fuel comprises at least 90% petrol.
5. The method according to any one of the preceding items, wherein said compression-ignition engine system is part of a motor vehicle.
6. The method according to any one of the preceding items, wherein said motor vehicle is selected from the group consisting of cars, buses, motorcycles, off-road vehicles, light trucks, regular trucks, ships, boats, hovercraft, submarines, heavy-duty vehicles, aircrafts.
7. The method according to any one of the preceding items, wherein said compression-ignition engine system is part of an electric generator.
8. The method according to any one of the preceding items, wherein said fuel supply reservoir is a tank.
9. The method according to any one of the preceding items, wherein adding said mixture to the fuel supply

reservoir results in said petrol-like fuel being modified into a motor fuel that can be ignited by a compression-ignition engine.

10. The method according to any one of the preceding items, wherein said mixture is stored in a closed container.

11. The method according to any one of the preceding items, further comprising shaking said closed container containing the mixture before addition of the mixture to the fuel supply reservoir.

12. The method according to any one of the preceding items, further comprising waiting for at least 2 minutes between addition of the mixture to the fuel supply reservoir and turning on the compression-ignition engine.

13. The method according to any one of the preceding items, wherein said mixture is added to a fuel supply reservoir resulting in a final lubricant concentration in the range of 0.005 to 0.5% in volume.

14. The method according to any one of the preceding items, wherein said mixture is added to a fuel supply reservoir resulting in a final lubricant concentration in the range of 0.013 to 0.5% in volume.

15. The method according to any one of the preceding items, wherein said mixture is added to a fuel supply reservoir resulting in a final cetane number improver concentration in the range of 0.45 to 10% in volume.

16. The method according to any one of the preceding items, wherein adding said mixture to the petrol-like fuel contained in the fuel supply reservoir results in a fuel having cetane number in the range of 40 and 65.

17. The method according to any one of the preceding items, wherein adding said mixture to the petrol-like fuel contained in the fuel supply reservoir results in a fuel having lubricity resulting in a wear scar diameter below 460 μm .

18. The method according to any one of the preceding items, wherein the reconditioning results in the coefficient of variation of IMEP being lower than 10%.

19. The method according to any one of the preceding items, wherein the reconditioning results in a coefficient of variation of IMEP in the range of 4 to 10% at 1 bar IMEP and in a coefficient of variation of IMEP in the range of 1 to 10% at 6 bar IMEP.

20. A closed container comprising a mixture consisting of:

- a. 0.25-10% v/v of a lubricant,
- b. 90-99.75% v/v of a cetane number improver, and
- c. an inert gas.

21. A closed container comprising a mixture consisting of:

- a. 0.1-10% v/v of a lubricant,
- b. 90-99.9% v/v of a cetane number improver, and
- c. an inert gas.

22. The container according to any one of items 20 to 21, wherein all gas within said container is an inert gas.

23. The container according to any one of items 20 and 22, wherein said inert gas is N₂.

24. The container according to any one of items 20 to 23, wherein all gas within said container is N₂.

25. The container according to any one of items 20 to 24, wherein the mixture comprises said lubricant in the range of 0.01 to 9% v/v, 0.25-9% v/v, such as in the range of 0.25-8% v/v, such as in the range of 0.25 to 7% v/v, such as in the range of 0.25 to 5% v/v, for example in the range of 0.1 to 4% v/v, such as in the range of 0.25 to 4% v/v, such as in the range of 0.25 to 3% v/v, for example in the range of 0.1 to 2% v/v, such as in the range of 0.25 to 2% v/v, such as in the range of 0.25 to 1.5% v/v, such as in the range of 0.25 to 1.2% v/v, such as in the range of 0.25 to 1% v/v, such as in the range of 0.25 to 0.6% v/v, such as in the range of 0.25 to 0.5% v/v, for example in the range of 0.1 to 0.5% v/v.

26. The container according to any one of items 20 to 25, wherein the mixture comprises said lubricant in the range of 0.1 to 10% v/v, for example 0.3-10% v/v, such as 0.4-10% v/v, such as in the range of 0.5 to 10% v/v, such as in the range of 0.6 to 10% v/v, such as in the range of 0.7-10% v/v, such as in the range of 0.8-10% v/v, such as in the range of 0.9-10% v/v, such as in the range of 1-10% v/v, such as in the range of 2-10% v/v, such as in the range of 3-10% v/v, such as in the range of 4-10% v/v, such as in the range of 5-10% v/v, such as in the range of 6-10% v/v, such as in the range of 7-10% v/v, such as in the range of 8-10% v/v, such as in the range of 9-10% v/v.

27. The method or the container according to any one of the preceding items, wherein the lubricant is a compound or mixture of compounds that reduce friction between surfaces in mutual contact.

28. The method or the container according to any one of the preceding items, wherein the lubricant comprises a polar functional group and a lipophilic moiety.

29. The method or the container according to any one of the preceding items, wherein the lubricant is fatty acid based or ester based.

30. The method or the container according to any one of the preceding items, wherein the lubricant comprises or consists of a fatty acid.

31. The method or the container according to any one of the preceding items, wherein the lubricant is selected from a group consisting of paraffinic hydrocarbons, naphthenic hydrocarbons, aromatic hydro-

carbons and triglyceride esters, wherein said hydrocarbons are modified with a polar functional group.

32. The method or the container according to any one of the preceding items, wherein the lubricant is a triglyceride ester selected from a group composed of canola oil, castor oil, palm oil, sunflower seed oil, rapeseed oil, tall oil and lanolin.

33. The method or the container according to any one of the preceding items, wherein the lubricant is selected from a group composed of AO 22TM, AO 24TM, AO 29TM, AO 30TM, AO 31TM, AO 32TM, AO 36TM, AO 36DTM, AO 37TM, AO 37DTM, DCI 4ATM, DCI 6ATM, DCI 11TM, DCI 28TM, and DCI 30TM, HITEC 4140ATM, 4142TM, 4898TM, 580TM, ONDEO-NALCO 5403TM, OLI 5015TM, OLI 5000, OLI 9000 and R655.

34. The method or the container according to any one of the preceding items, wherein the mixture comprises said cetane number improver in the range of 90 to 99.9% v/v, for example in the range of 90 to 99.5% v/v, such as in the range of 90-99.3% v/v, such as in the range of in the range of 90-99.1% v/v, such as in the range of in the range of 90-98.9% v/v, such as in the range of 90-98.7% v/v, such as in the range of 90-98.5% v/v, such as in the range of 90-98.3% v/v, such as in the range of 90-98.1% v/v, such as in the range of 90-97.9% v/v, such as in the range of 90-97.5% v/v, such as in the range of 90-97.3% v/v, such as in the range of 90-97.1% v/v, such as in the range of 90-96.9% v/v, such as in the range of 90-96.7% v/v, such as in the range of 90-96.5% v/v, such as in the range of 90-96.3% v/v, such as in the range of 90-96.1% v/v, such as in the range of 90-95.9% v/v, such as in the range of 90-95.7% v/v, such as in the range of 90-95.5% v/v, such as in the range of 90-95.3% v/v, such as in the range of 90-95.1% v/v, such as in the range of 90-94.9% v/v, such as in the range of 90-94.7% v/v, such as in the range of 90-94.5% v/v, such as in the range of 90-94.3% v/v, such as in the range of 90-94.1% v/v, such as in the range of 90-93.9% v/v, such as in the range of 90-93.7% v/v, such as in the range of 90-93.5% v/v, such as in the range of 90-93.3% v/v, such as in the range of 90-93.1% v/v, such as in the range of 90-92.9% v/v, such as in the range of 90-92.7% v/v, such as in the range of 90-92.5% v/v, such as in the range of 90-92.3% v/v, such as in the range of 90-92.1% v/v, such as in the range of 90-91.9% v/v, such as in the range of 90-91.7% v/v, such as in the range of 90-91.5% v/v, such as in the range of 90-91.3% v/v, such as in the range of 90-91.1% v/v, such as in the range of 90-90.9% v/v, such as in the range of 90-90.7% v/v, such as in the range of 90-90.5% v/v.

35. The method or the container according to any one of the preceding items, wherein the mixture comprises said cetane number improver in the range of 90 to 99.9% v/v, for example in the range of

90.5-99.5% v/v, such as in the range of 91-99.5% v/v, such as in the range of 91.5-99.5% v/v, such as in the range of 92-99.5% v/v, such as in the range of 92.5-99.5% v/v, such as in the range of 93-99.5% v/v, such as in the range of 93.5-99.5% v/v, such as in the range of 94-99.5% v/v, such as in the range of 94.5-99.5% v/v, such as in the range of 95-99.5% v/v, such as in the range of 95.5-99.5% v/v, such as in the range of 96-99.5% v/v, such as in the range of 96.5-99.5% v/v, such as in the range of 97-99.5% v/v, such as in the range of 97.5-99.5% v/v, such as in the range of 98 to 99.9% v/v, for example in the range of 98-99.5% v/v, such as in the range of 98.5-99.5% v/v, such as in the range of 99-99.5% v/v, for example in the range of 99 to 99.9% v/v.

36. The method or the container according to any one of the preceding items, wherein the cetane number improver is a compound or mixture of compounds that when added to a fuel results in an increase in the cetane number of that fuel.

37. The method or the container according to any one of the preceding items, wherein the cetane number improver has a cetane number higher than the cetane number of the petrol-like fuel.

38. The method or the container according to any one of the preceding items, wherein the cetane number improver is a hydrocarbon comprising a straight chain of at least 7 carbon atoms and/or an ether group and/or a nitrate group.

39. The method or the container according to any one of the preceding items, wherein the cetane number improver is selected from a group consisting of organic nitrates, organic peroxides and hydrocarbons comprising at least a straight chain of 7 carbon atoms.

40. The method or the container according to any one of the preceding items, wherein the cetane number improver is selected from a group composed of di-tertiary butyl peroxide (DTBP), fatty alcohol nitrate ester (FANE) and 2-ethylhexyl nitrate (2-EHN).

41. The method or the container according to any one of the preceding items, wherein the cetane number improver is 2-ethylhexyl nitrate (2-EHN).

42. The method or the container according to any one of the preceding items, further comprising blending the components to obtain a homogeneous mixture.

43. The container according to any one of items 20 to 42, wherein the inert gas is nitrogen.

44. The method according to any one of items 1 to 19, wherein the lubricant is as defined in any one of items 27 to 33.

45. The method according to any one of items 1 to 19, wherein the cetane number improver is as defined in any one of items 36 to 41.

46. The method according to any one of items 1 to 19, 27 to 42 and 44 to 45, wherein the method does

not involve a step of agitating or physical mixing.

47. The method according to any one of items 1 to 19, 27 to 42 and 44 to 46, wherein said homogeneous mixture is mixed with said petrol-like fuel at the most 10 min., preferably at the most 5 min. after adding said mixture to the fuel reservoir.

48. The method according to any one of items 1 to 19, 27 to 42 and 44 to 47, wherein the difference in turbidity of the cetane number improver, lubricant and petrol-like fuel mixture compared to a fully mixed mixture of cetane number improver, lubricant and petrol-like fuel is reduced by at least 90% within 10 min., preferably within 5 min. after addition of said homogeneous mixture.

49. Use of a homogeneous mixture comprising 0.25-10% v/v of a lubricant and 90-99.75% v/v of a cetane number improver for reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel.

50. Use of a homogeneous mixture comprising 0.1-10%v/v of a lubricant and 90-99.75% v/v of a cetane number improver for reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel.

51. Use according to any one of items 49 to 50, wherein the homogeneous mixture is a mixture as defined in any one of items 20 to 48.

35 Examples

Example 1. Container comprising the fuel additive mixture

40 **[0065]** A container filled with a mixture of:

90-99% gasoline, to which a pre-mixed
4-4.95% 2-EHN cetane number improver and
0.1-0.5% tall-oil based lubricity additive R655 from
Infineum

was allowed to stand for three weeks in a container in order to check whether any sedimentation or other visible degradation would occur.

50 **[0066]** Results: No sedimentation or change of colour was observed.

Example 2. Diesel engine running on commercial gasoline after addition of fuel additive mixture

55 **[0067]** Reference tests with commercial Swedish MK1 diesel fuel have been conducted on a 2 litre 4-cylinder commercial passenger car diesel engine with common

rail fuel injection to confirm that the engine behaves according to the manufacturer's specifications. The engine was fully instrumented in a research lab including cylinder pressure measurement capability.

[0068] A second experiment was conducted on the same diesel engine used in the reference tests, but with a mix of 95 octane commercial gasoline and the fuel additive, which consisted of a mixture of 2-EHN cetane number improver and tall-oil based lubricity additive. The engine was operated in six operating points ranging from idle at 1 bar indicated mean effective pressure (IMEP) to 6 bar IMEP. In this experiment the gasoline, cetane improver and lubricity additive were all premixed in a homogeneous solution where the cetane improver amounted to 5% of the total mixture and the lubricity additive amounted to 160 ppm. The coefficient of variation of IMEP, COV(IMEP), which is a measure of the combustion variability, decreased with engine load from 6% at idle to 2% at 6 bar IMEP. The brake efficiency of the engine stayed between 30% and 40% for the operating points at or above 3 bar IMEP. The engine operation is illustrated in Figure 1 and Figure 2.

[0069] If the engine is run with only 95 octane commercial gasoline, the engine will stop after a while and no combustion occur; the high pressure pumps are damaged.

[0070] Results: The engine was operated for a total of 40 minutes with gasoline mixed with the fuel additive. No significant difference in terms of cylinder pressure, accumulated heat release and COV(IMEP) was observed between the engine operated with gasoline and fuel additive and the one operated with the reference fuel.

Example 3. Blending of the mixture and gasoline

[0071] A well-mixed blend of 2-EHN cetane number improver and tall-oil based lubricity additive, also referred to as fuel additive, was added by pouring into regular gasoline. The fuel additive contained 2-EHN cetane number improver and tall-oil based lubricity additive in the right proportions to obtain a final concentration of the compounds as described in Example 2. The test was carried out at 10°C. Figure 3a shows the gasoline and the premixed additive while pouring, the two phases are not mixed and cloudiness can be seen in the flask. Figure 3b shows the gasoline comprising the fuel additive, two minutes after pouring. No cloudiness can be seen, indicating that the mixing between gasoline and additive is complete and two components are now in the form of a homogeneous mixture.

[0072] Results: The fuel additive blends in a homogeneous manner with gasoline within 2 minutes without need for shaking and/or stirring the flask.

Example 4

[0073] It is important that the mixture of cetane number improver and lubricant mixes spontaneously with the pet-

rol-like fuel present in the fuel supply reservoir within an acceptable time frame.

[0074] To test this, a homogenous mixture of a cetane number improver and a lubricant is added to petrol in a glass container without physical agitation and the turbidity is measured as a function of time. As a control, the same cetane number improver and lubricant is added to petrol in the same ratio and the mixture is mixed thoroughly by physical agitation and the turbidity is determined.

[0075] The difference in turbidity between the test mixture and the control is determined. If the turbidity difference compared to the control decreases by at least 90% within five minutes after adding the mixture, the mixture can be considered to self-mix with the petrol-like fuel in a satisfactory way.

[0076] The turbidity is measured using a turbidity tube or an optical turbidity sensor based on light scattering.

[0077] Any mixture of cetane number improver and lubricant may be tested. In particular, a homogenous mixture between 2-ethyl-hexyl nitrate (2-EHN) and tall-oil based lubricity additive is tested.

[0078] Different ratios of cetane number improver and lubricants are tested including the following:

1. 5%vol 2-EHN - 160ppm lubricant
2. 5%vol 2-EHN - 100ppm lubricant
3. 2.5%vol 2-EHN - 160ppm lubricant
4. 2.5%vol 2-EHN - 100ppm lubricant
5. 3.75%vol 2-EHN - 130ppm lubricant

[0079] The % and ppm provided are the concentration in the final mixture of petrol, 2-EHN and lubricant.

References

- [0080]** Wei DP and Spikes HA, 1999. The lubricity of gasoline. Tribology transactions 42, 4, p. 813-823.
WO 2005/035694 A1
US 2013/0298452 A1
US Patent No. 5,891,203

Claims

1. A method of reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel, said method comprising the steps of:
 - a. providing a homogeneous mixture comprising 0.1-10% v/v of a lubricant and 90-99.9% v/v of a cetane number improver,
 - b. adding said mixture to the fuel supply reservoir.

2. The method according to any one of the preceding claims, wherein said petrol-like fuel comprises at least 90% petrol.
3. The method according to any one of the preceding claims, wherein said compression-ignition engine system is part of a motor vehicle.
4. The method according to any one of the preceding claims, wherein said mixture is added to a fuel supply reservoir resulting in a final lubricant concentration in the range of 0.005 to 0.5% in volume.
5. The method according to any one of the preceding claims, wherein said mixture is added to a fuel supply reservoir resulting in a final cetane number improver concentration in the range of 0.45 to 10% in volume.
6. The method according to any one of the preceding items, wherein the reconditioning results in the coefficient of variation of IMEP being lower than 10%.
7. A closed container comprising a mixture consisting of:
 - a. 0.1-10% v/v of a lubricant,
 - b. 90-99.9% v/v of a cetane number improver, and
 - c. an inert gas,
 wherein all gas within said container is an inert gas.
8. The container according to claim 7, wherein said inert gas is N₂.
9. The method or the container according to any one of the preceding claims, wherein the lubricant is a compound or mixture of compounds that reduce friction between surfaces in mutual contact.
10. The method or the container according to any one of the preceding claims, wherein the lubricant comprises a compound having a polar functional group attached to a lipophilic group.
11. The method or the container according to any one of the preceding claims, wherein the lubricant is a triglyceride ester selected from a group composed of canola oil, castor oil, palm oil, sunflower seed oil, rapeseed oil, tall oil and lanolin or the lubricant is selected from a group composed of AO 22TM, AO 24TM, AO 29TM, AO 30TM, AO 3TM, AO 32TM, AO 36TM, AO 36DTM, AO 37TM, AO 37DTM, DCI 4ATM, DCI 6ATM, DCI 11TM, DCI 28TM, and DCI 30TM, HITEC 4140ATM, 4142TM, 4898TM, 580TM, ONDEO-NALCO 5403TM, OLI 5015TM, OLI 5000, OLI 9000 and R655.
12. The method or the container according to any one of the preceding claims, wherein the cetane number improver is a compound or mixture of compounds that when added to a fuel results in an increase in the cetane number of that fuel.
13. The method or the container according to any one of the preceding claims, wherein cetane number improver is a straight chain of at least 7 carbon atoms and/or an ether group and/or a nitrate group.
14. The method or the container according to any one of the preceding claims, wherein the cetane number improver is selected from a group composed of di-tertiary butyl peroxide (DTBP), fatty alcohol nitrate ester (FANE) and 2-ethylhexyl nitrate (2-EHN).
15. Use of a homogeneous mixture comprising 0.1-10% v/v of a lubricant and 90-99.9% v/v of a cetane number improver for reconditioning a compression-ignition engine system, said compression-ignition engine system comprising a compression-ignition engine connected to a fuel supply reservoir, wherein the fuel supply reservoir contains a petrol-like fuel.

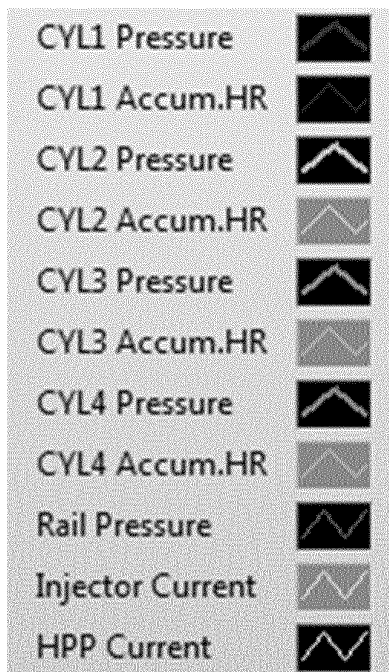
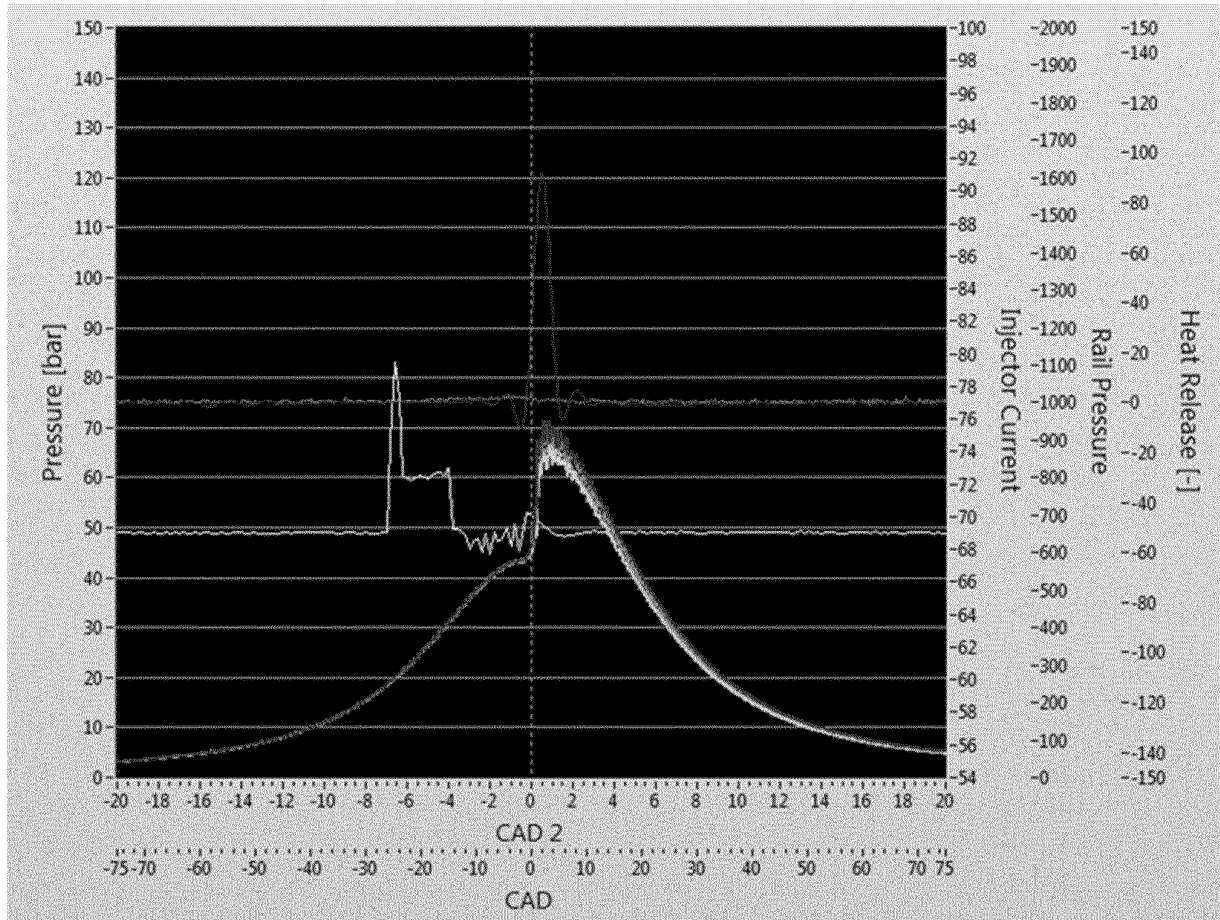


Fig. 1

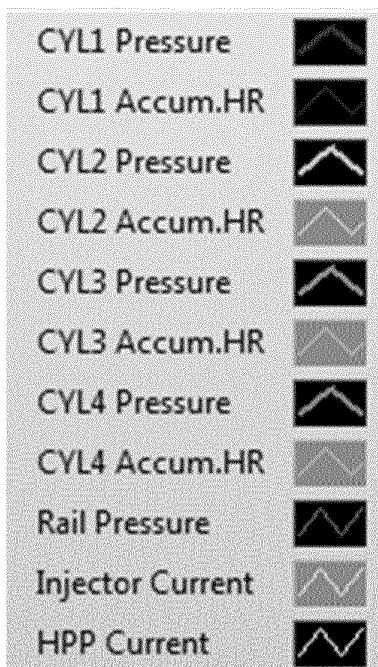
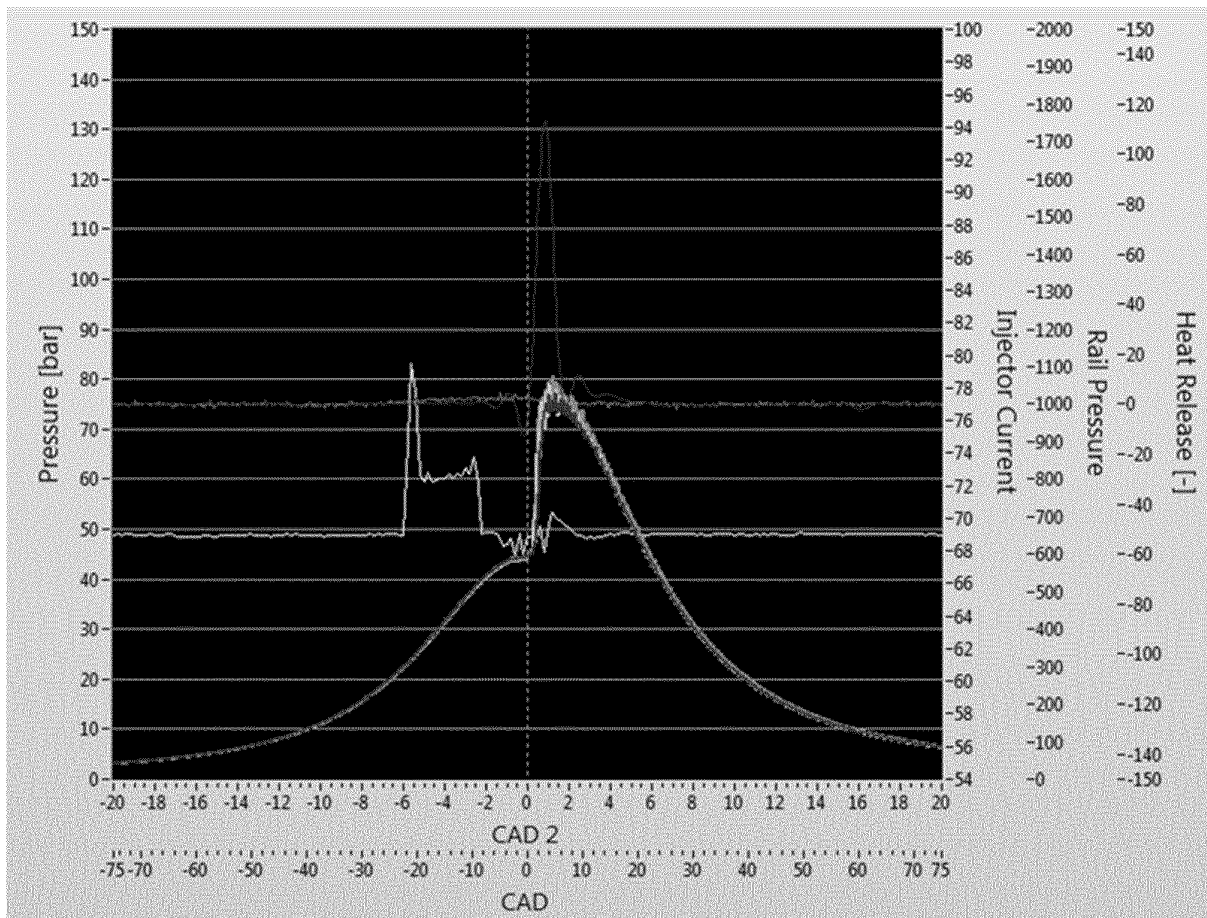
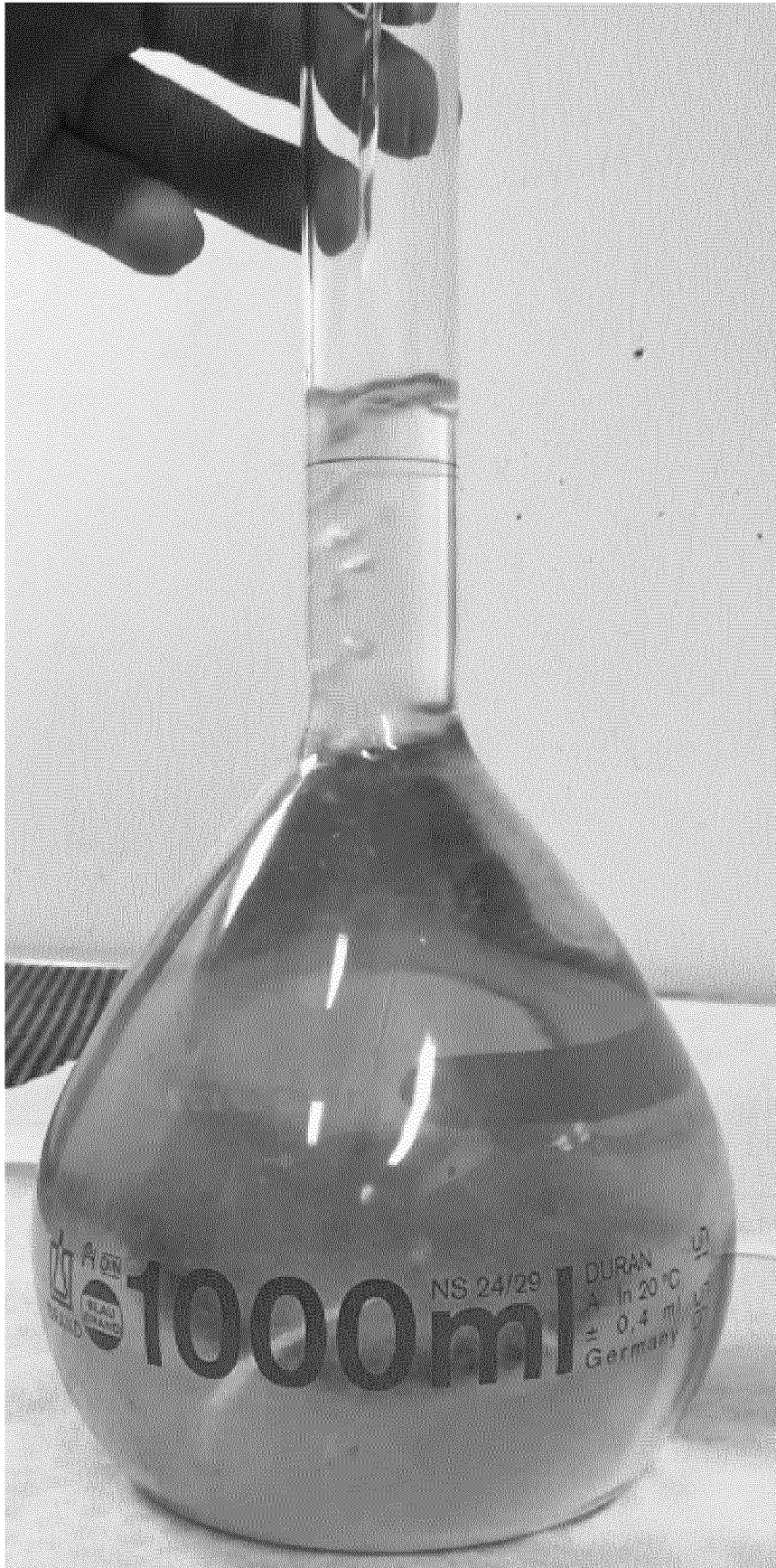


Fig. 2



A.



B.



EUROPEAN SEARCH REPORT

Application Number
EP 17 16 3529

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 32 08 077 A1 (CHEVRON RES [US]) 11 November 1982 (1982-11-11) * figures 1,2 *	7-14	INV. C10L1/10
X	GERBEN DOORNBOS ET AL: "A First Implementation of an Efficient Combustion Strategy in a Multi Cylinder Two-Stage Turbo CI-Engine Producing Low Emissions While Consuming a Gasoline/EHN Blend", SAE TECHNICAL PAPER SERIES, vol. 1, 15 September 2013 (2013-09-15), XP055375210, US ISSN: 0148-7191, DOI: 10.4271/2013-24-0103 * paragraphs [Test] - [equipmentandSet], [Fuels]; figure 1; tables 2,3 *	1-6,15	
Y	[Fuels]; figure 1; tables 2,3 *	1-6,15	
Y	R Cracknell ET AL: "Exploring a Gasoline Compression Ignition (GCI) engine concept", Concauwe Report 13/14, 1 December 2014 (2014-12-01), XP055375373, Brussels Retrieved from the Internet: URL:https://www.concauwe.eu/wp-content/uploads/2017/01/report13_14-exploring-a-gasoline-compression-ignition-gci-engine-concept.pdf [retrieved on 2017-05-23] * paragraphs [02.3], [02.4], [06.1] *	1-6,15	TECHNICAL FIELDS SEARCHED (IPC) C10L
A	EP 2 578 529 A1 (BOSCH GMBH ROBERT [DE]) 10 April 2013 (2013-04-10) * paragraphs [0002], [0024] - [0041]; claim 1; figures 1,2 *	1-6,15	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 May 2017	Examiner Pöllmann, Klaus
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 16 3529

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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23-05-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 3208077 A1	11-11-1982	BE 892392 A1	01-07-1982
		CA 1202580 A	01-04-1986
		DE 3208077 A1	11-11-1982
		DK 97382 A	11-09-1982
		FR 2501632 A1	17-09-1982
		GB 2098572 A	24-11-1982
		IT 1150265 B	10-12-1986
		NL 8200965 A	01-10-1982

EP 2578529 A1	10-04-2013	DE 102011084074 A1	11-04-2013
		EP 2578529 A1	10-04-2013

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20130298452 A1 [0004] [0080]
- WO 2005035694 A [0004]
- US 5891203 A [0004] [0080]
- US 5349188 A [0014]
- WO 2005035694 A1 [0080]

Non-patent literature cited in the description

- **WEI DP ; SPIKES HA.** The lubricity of gasoline. *Tri-bology transactions*, 1999, vol. 42 (4), 813-823 [0080]