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(54) **DIESEL FUEL COMPOSITIONS**

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(57) **ABSTRACT**

The use of a detergent-containing fuel additive in a diesel fuel composition, for the purpose of reducing engine power loss and/or reversing a previously incurred power loss, and optionally also for reducing smoke and/or particulate emissions. Also provided is a method for assessing the performance of a candidate diesel fuel composition based on its ability to reduce or reverse power loss, and a diesel fuel composition containing a detergent at an active matter concentration of between 100 and 500 ppmw.

DIESEL FUEL COMPOSITIONS

FIELD OF THE INVENTION

[0001] The present invention relates to diesel fuel compositions, their preparation and their use in diesel engines, and to the use of additives in diesel fuel compositions.

BACKGROUND OF INVENTION

[0002] Some compression-ignition (diesel) engines appear to suffer power loss after a period of use. The phenomenon is to date poorly understood, but seems particularly to affect direct injection (DI) diesel engines.

[0003] The problem may also be more marked when using fuels with a low volumetric energy content, for example low or ultra low sulphur fuels or fuels with a relatively low density (such as those containing Fischer-Tropsch methane condensation products). Such fuels are often used where lower vehicle emissions are a priority, or where there are constraints on the nature or level of undesirable fuel components.

DESCRIPTION OF THE INVENTION

[0004] It has now surprisingly been found that the use of certain additives in a diesel fuel can reduce and in some cases reverse power loss. A suitably additivated fuel can therefore be used to help maintain and/or improve engine performance. The additives may in particular be used to enhance performance of an otherwise relatively low energy fuel.

[0005] The use of such additives has moreover been found to give other benefits, including reduced smoke and particulate emissions.

[0006] According to a first aspect of the present invention there is provided the use of a detergent-containing fuel additive in a diesel fuel composition, for the purpose of reducing subsequent power loss in a diesel engine into which the fuel composition is introduced.

[0007] According to a second aspect of the present invention there is provided the use of a detergent-containing fuel additive in a diesel fuel composition, for the purpose of reversing a previously incurred power loss in a diesel engine into which the fuel composition is introduced.

[0008] In this context, "reducing" includes complete prevention, and "reversing" embraces both complete and partial reversal. "Use" of the additive in a fuel composition means incorporating the additive into the fuel composition, conveniently before the composition is introduced into the engine.

[0009] Power loss in the engine may be manifested by, for example, a reduction in tractive effort and/or acceleration rate in a vehicle being driven by the engine. Conversely, reversal of a previously incurred power loss will mean an increase in engine power output, which may be manifested by an increase in vehicle tractive effort and/or a reduction in acceleration times. A reduction in subsequent power loss will inhibit the reduction in tractive effort and/or acceleration rate which would otherwise have been expected, for instance extrapolating from previous performance, in particular compared to that which would have occurred had the engine been run on an unadditivated fuel or a fuel containing less, or no, detergent. In accordance with the present invention, therefore, a detergent-containing additive may be incorporated into a fuel composition with the aim of achieving these indirect effects.

DETAILED DESCRIPTION OF THE INVENTION

[0010] The present invention is particularly applicable where the fuel composition is used or intended to be used in a direct injection diesel engine, for example of the rotary pump, electronic unit injector or common rail type. It may be of particular value for rotary pump engines, in which power loss can be especially marked, and in other diesel engines which rely on mechanical actuation of the fuel injectors and/or a low pressure pilot injection system.

[0011] The diesel fuel composition may be of an otherwise conventional type, typically comprising liquid hydrocarbon middle distillate fuel oils. However it may in particular comprise a low or ultra low sulphur content fuel, for instance containing at most 500 ppmw (parts per million by weight) sulphur, preferably less than 300 ppmw, more preferably less than 250 ppmw, still more preferably no more than 100 ppmw, most preferably no more than 60 or 50 or even 10 ppmw. It may be, or contain a proportion (for instance, 10% v/v or more) of, reaction products of a Fischer-Tropsch methane condensation process such as the process known as Shell Middle Distillate Synthesis (SMDS)—such reaction products suitably have boiling points within the typical diesel fuel range (between about 150 and 370° C.), a density of between about 0.76 and 0.79 g/cm^3 at 15° C., a cetane number greater than 72.7 (typically between about 75 and 82), a sulphur content of less than 5 ppmw, a viscosity between about 2.9 and 3.7 centistokes (mm^2/s) at 40° C. and an aromatics content of no greater than 1% w/w.

[0012] The diesel fuel composition may comprise a relatively low density fuel, such as a fuel having a density of less than 0.840 g/cm^3, preferably less than 0.835 g/cm^3, at 15° C. In fuels of these types, the detergent-containing additive may be used for the purpose of compensating for the fuel's inherently lower energy content. In other words, the additive may be used generally to increase the power provided by a fuel composition during subsequent use.

[0013] The additive must contain a detergent, by which is meant an agent (suitably a surfactant) which can act to remove, and/or to prevent the build up of, combustion related deposits within the engine, in particular in the fuel injection system such as in the injector nozzles. Such materials are sometimes referred to as dispersant additives. Although we do not wish to be bound by this theory, the build up of combustion related deposits is now believed to be at least partially responsible for power loss in direct injection diesel engines.

[0014] The detergent is preferably included in the fuel composition at a concentration sufficient to recover, at least partially, power lost in the engine during a period of running using another fuel (typically unadditivated, or containing only low levels of, if any, detergent). This is generally a concentration sufficient to remove, at least partially, combustion related deposits which have built up in the engine's fuel injection system, in particular in the injector nozzles. It will depend on the nature of the detergent, but preferred values lie in the range 100 to 500 ppmw active matter detergent based on the overall additivated fuel composition, more preferably 150 to 300 ppmw. In the case of most commercially available detergent-containing diesel fuel additives, this will mean incorporating the additive at levels higher than the standard recommended single treat rate, for example between 1.2 and 3 times, preferably between 1.5 and 2.5 times, such as about twice the standard single treat rate.

[0015] Lower detergent levels (for example, corresponding to between 0.5 and 1.2 times, preferably the same as, the standard single treat rate) may be used to reduce, ideally to prevent, further power losses as opposed to reversing previously incurred losses.

[0016] Preferably the quantity of detergent-containing additive used is sufficient to recover at least 25%, more preferably at least 50% or 75% or 90% or 95%, most preferably 100%, of power lost in the engine during a previous period of use with a different fuel composition, when the engine is subsequently run on the detergent-containing fuel composition for a comparable number of miles and under comparable driving conditions. Even more preferably, the amount of detergent present is sufficient to provide the stated recovery of power (which may equate to a corresponding reduction in combustion related deposits) when the engine is subsequently run on the detergent-containing fuel composition for 75%, yet more preferably 50% or even 40% or 30%, of the number of miles covered on the previous fuel, again under comparable driving conditions. The previous fuel may for instance be an unadditivated diesel fuel composition, or one containing no, or no more than 50 or even 20 ppmw, active matter detergent.

[0017] Alternatively, the detergent-containing additive may be used in a quantity sufficient to reduce by at least 25%, preferably at least 50%, more preferably at least 75%, most preferably at least 90%, such as by 100%, the amount of power loss incurred (which may equate to a corresponding increase in combustion related deposits) when running the engine on the fuel composition, as compared to that incurred when running the engine, under comparable driving conditions, on an unadditivated fuel composition or one containing no, or no more than 50 or 20 ppmw, active matter detergent.

[0018] As explained above, engine power may be assessed with reference to, for example, vehicle tractive effort and/or acceleration times.

[0019] The degree of power recovery achievable by using, in accordance with the invention, a detergent-containing additive may conveniently be assessed using a method according to the seventh aspect of the invention, described below.

[0020] Detergent-containing diesel fuel additives are known and commercially available, for instance from Infineum (eg, F7661 and F7685) and Octel (eg, OMA 4130D). In the past such additives have been added to diesel fuels at relatively low levels (their "standard" treat rates providing typically less than 100 ppmw active matter detergent in the overall additivated fuel composition) intended merely to reduce or slow the build up of engine deposits. The additives have not to our knowledge been used for the purpose of increasing engine power, and in particular not at levels high enough to reverse previously incurred power loss. That they are capable of achieving this is especially surprising.

[0021] Examples of detergents suitable for use in fuel additives for the present purpose include polyolefin substituted succinimides or succinamides of polyamines, for instance polyisobutylene succinimides or polyisobutylene amine succinamides, aliphatic amines, Mannich bases or amines and polyolefin (eg, polyisobutylene) maleic anhydrides. Succinimide dispersant additives are described for example in GB-A-960493, EP-A-0147240, EP-A-0482253, EP-A-0613938, EP-A-0557561 and WO-A-98/42808. Particularly preferred are polyolefin substituted succinimides such as polyisobutylene succinimides.

[0022] The additive may contain other components in addition to the detergent. Examples are lubricity enhancers; dehazers, eg, alkoxylated phenol formaldehyde polymers such as those commercially available as NALCO™ EC5462A (formerly 7D07) (ex Nalco), and TOLAD™ 2683 (ex Petrolite); anti-foaming agents (eg, the polyether-modified polysiloxanes commercially available as TEGOPREN™ 5851 and Q 25907 (ex Dow Corning), SAG™ TP-325 (ex OSi), or RHODORSIL™ (ex Rhone Poulenc)); ignition improvers (cetane improvers) (eg, 2-ethylhexyl nitrate (EHN), cyclohexyl nitrate, di-tert-butyl peroxide and those disclosed in U.S. Pat. No. 4,208,190 at column 2, line 27 to column 3, line 21); anti-rust agents (eg, that sold commercially by Rhein Chemie, Mannheim, Germany as "RC 4801", a propane-1, 2-diol semi-ester of tetrapropenyl succinic acid, or polyhydric alcohol esters of a succinic acid derivative, the succinic acid derivative having on at least one of its alpha-carbon atoms an unsubstituted or substituted aliphatic hydrocarbon group containing from 20 to 500 carbon atoms, eg, the pentaerythritol diester of polyisobutylene-substituted succinic acid); corrosion inhibitors; reodorants; anti-wear additives; anti-oxidants (eg, phenolics such as 2,6-di-tert-butylphenol, or phenylenediamines such as N,N'-di-sec-butyl-p-phenylenediamine); and metal deactivators.

[0023] It is particularly preferred that the additive include a lubricity enhancer, especially when the fuel composition has a low (eg, 500 ppmw or less) sulphur content. In the additivated fuel composition, the lubricity enhancer is conveniently present at a concentration between 50 and 1000 ppmw, preferably between 100 and 1000 ppmw. Suitable commercially available lubricity enhancers include EC 832 and PARADYNE™ 655 (ex Infineum), HITEC™ E580 (ex Ethyl Corporation), VEKTRON™ 6010 (ex Infineum) and amide-based additives such as those available from the Lubrizol Chemical Company, for instance LZ 539 C. Other lubricity enhancers are described in-the patent literature, in particular in connection with their use in low sulphur content diesel fuels, for example in:

[0024] the paper by Danping Wei and H. A. Spikes, "*The Lubricity of Diesel Fuels*", Wear, III (1986) 217-235;

[0025] WO-A-95/33805 (Exxon)—cold flow improvers to enhance lubricity of low sulphur fuels;

[0026] WO-A-94/17160 (Exxon)—certain esters of a carboxylic acid and an alcohol wherein the acid has from 2 to 50 carbon atoms and the alcohol has 1 or more carbon atoms, particularly glycerol monooleate and di-isodecyl adipate, as fuel additives for wear reduction in a diesel engine injection system;

[0027] U.S. Pat. No. 5,484,462 (Texaco)—mentions dimerized linoleic acid as a commercially available lubricity agent for low sulphur diesel fuel (column 1, line 38), and itself provides aminoalkylmorpholines as fuel lubricity improvers;

[0028] U.S. Pat. No. 5,490,864 (Texaco)—certain dithiophosphoric diester-dialcohols as anti-wear lubricity additives for low sulphur diesel fuels; and

[0029] WO-A-98/01516—certain alkyl aromatic compounds having at least one carboxyl group attached to their aromatic nuclei, to confer anti-wear lubricity effects particularly in low sulphur diesel fuels.

[0030] It is also preferred that the additive contain an anti-foaming agent, more preferably in combination with an anti-rust agent and/or a corrosion inhibitor and/or a lubricity additive.

[0031] Unless otherwise stated, the (active matter) concentration of each such additional component in the additivated fuel composition is preferably up to 1% w/w, more preferably in the range from 5 to 1000 ppmw, advantageously from 75 to 300 ppmw, such as from 95 to 150 ppmw.

[0032] The (active matter) concentration of any dehazer in the fuel composition will preferably be in the range from 1 to 20 ppmw, more preferably from 1 to 15 ppmw, still more preferably from 1 to 10 ppmw and advantageously from 1 to 5 ppmw. The (active matter) concentrations of other components (with the exception of the ignition improver) will each preferably be in the range from 0 to 20 ppmw, more preferably from 0 to 10 ppmw. The (active matter) concentration of any ignition improver present will preferably be between 0 and 600 ppmw and more preferably between 0 and 500 ppmw, conveniently between 300 and 500 ppmw.

[0033] The additive will typically contain the detergent, optionally together with other components as described above, and a diesel fuel-compatible diluent, which may be a carrier oil (eg, a mineral oil), a polyether, which may be capped or uncapped, a non-polar solvent such as toluene, xylene, white spirits and those sold by member companies of the Royal Dutch/Shell Group under the trade mark "SHELLSOL", and/or a polar solvent such as an ester and, in particular, an alcohol, eg, hexanol, 2-ethylhexanol, decanol, isotridecanol and alcohol mixtures such as those sold by member companies of the Royal Dutch/Shell Group under the trade mark "LINEVOL", especially LINEVOL™ 79 alcohol which is a mixture of C_{7-9} primary alcohols, or the C_{12-14} alcohol mixture commercially available from Sidobre Sinnova, France under the trade mark "SIPOL".

[0034] The additive may be suitable for use in heavy and/or light duty diesel engines.

[0035] Use of a detergent-containing additive, in accordance with the present invention, may give rise to additional benefits associated with engine emissions, in particular lower smoke levels and lower particulate mass. Previously in diesel fuels a reduction in emissions has typically been accompanied by a reduction in power. It has, however, surprisingly been found that a detergent-containing additive may be used both to reduce smoke and/or particulate emissions, whilst at the same time (despite the fact that the additive will generally lower the density of the fuel composition) increasing or at least maintaining power levels. This dual action is a further feature of the present invention. It may be put to particular use in higher density fuel compositions (which have previously been associated with higher smoke and particulate emissions), to improve their environmental performance but without a compromise in power output.

[0036] The present invention thus also provides, according to a third aspect, the use of a detergent-containing fuel additive in a diesel fuel composition, for the purpose of reducing smoke and/or particulate emissions in a diesel engine into which the fuel composition is introduced. More preferably, the use has the purpose of achieving the concurrent effects of (a) a reduction and/or reversal of power loss (as defined above), and/or an increase in power output, and (b) reduced smoke and/or particulate emissions. Reduced emissions may conveniently be identified with reference to the unadditivated diesel fuel composition.

[0037] When the present invention is applied in this manner, it may be desirable for the unadditivated fuel composition to be of a relatively high density, for example greater than 0.845 g/cm^3 at 15° C.

[0038] A fourth aspect of the present invention provides a method of operating a diesel engine, and/or a vehicle which is driven by a diesel engine, which method involves introducing into the combustion chambers of the engine a diesel fuel composition incorporating a detergent-containing fuel additive, for one or more of the following purposes:

[0039] a) reducing subsequent power loss in the engine;

[0040] b) reversing a previously incurred power loss in the engine; or

[0041] c) reducing smoke and/or particulate emissions from the engine.

[0042] The engine type, the nature of the diesel fuel composition, the nature and concentration of the detergent in the fuel composition as well as of other components in the additive, and the ways in which power and emission levels may be assessed, may all be as described above in connection with the first aspect of the present invention.

[0043] According to a fifth aspect of the present invention, there is provided a diesel fuel composition which includes a major proportion of a fuel for an internal combustion engine of the compression ignition type, and a minor proportion of a detergent-containing additive, wherein the active matter detergent concentration in the composition is between 100 and 500 ppmw.

[0044] By "minor proportion" is meant preferably less than 1% w/w of the fuel composition, more preferably less than 0.5% w/w (5000 ppmw) and most preferably less than 0.2% w/w (2000 ppmw); references to "major proportion" may be construed accordingly. Preferred detergent concentrations and types are as described in connection with the first aspect of the present invention, as are other features of the fuel and the detergent-containing additive. In particular, the diesel fuel composition preferably contains between 150 and 300 ppmw active matter detergent.

[0045] The fuel may be any fuel suitable for use in a diesel engine. It will typically have an initial distillation temperature of about 160° C. and a final distillation temperature of between 290 and 360° C., depending on its grade and use.

Vegetable oils may also be used as diesel fuels per se or in blends with hydrocarbon fuels.

[0046] The fuel may in particular be a low or ultra low sulphur content fuel, or contain a proportion (for instance, 10% v/v or more) of, reaction products of a Fischer-Tropsch methane condensation process such as the process known as Shell Middle Distillate Synthesis (SMDS), as described in connection with the first aspect of the present invention.

[0047] The fuel may itself be additivated (additive-containing) or unadditivated (additive-free). If additivated, it will contain minor amounts of one or more additives selected for example from anti-static agents, pipeline drag reducers, flow improvers (eg, ethylene/vinyl acetate copolymers or acrylate/maleic anhydride copolymers) and wax anti-settling agents (eg, those commercially available under the Trade Marks "PARAFLOW" (eg, PARAFLOW™ 450, ex Infineum), "OCTEL" (eg, OCTEL™ W 5000, ex Octel) and "DODIFLOW" (eg, DODIFLOW™ v 3958, ex Hoechst).

[0048] In accordance with a sixth aspect of the present invention, there is provided a method of operating a diesel engine, and/or a vehicle which is driven by a diesel engine, which method involves introducing into the combustion chambers of the engine a diesel fuel composition according to the fifth aspect.

[0049] A seventh aspect of the present invention provides a process for the preparation of a diesel fuel composition according to the fifth aspect, which process involves admixing a major proportion of a diesel engine fuel, as described above, with a minor proportion of a detergent-containing additive, also as described above. Said minor proportion is sufficient to give an active matter detergent concentration in the fuel composition of between 100 and 500 ppmw.

[0050] According to an eighth aspect, the present invention provides a method for assessing the performance of a candidate diesel fuel composition, comprising the steps of:

[0051] 1) measuring power output for a (preferably direct injection) diesel engine running on a "standard" diesel fuel composition, which "standard" fuel composition is either unadditivated or, if additivated, contains less than 50 or preferably less than 20 ppmw active matter detergent;

[0052] 2) subjecting the engine to a first driving cycle by running it for a first number of miles on the standard fuel composition;

[0053] 3) measuring engine power after the first driving cycle;

[0054] 4) calculating the reduction in engine power during the first driving cycle;

[0055] 5) provided that significant power loss is observed during the first driving cycle, subjecting the engine to a second driving cycle by running it for a second number of miles on the candidate diesel fuel composition;

[0056] 6) measuring engine power after the second driving cycle;

[0057] 7) calculating the reduction in engine power (if any) during the second driving cycle; and

[0058] 8) if applicable, calculating the extent of engine power recovery during the second driving cycle.

[0059] The test should proceed only if significant power loss is observed during the first driving cycle. By "significant" power loss is meant at least a 2% reduction in power, preferably at least 4%, more preferably at least 5% or 7%. In case of a lower or no observed power loss, it may be appropriate to repeat the test using a different fuel injector system in the engine, and/or a different vehicle, since power losses have in cases been found to be sensitive to such variables. Higher power losses, for instance 10% or more, may be observed when testing indirect injection diesel engines.

[0060] The "standard" fuel composition is suitably a low or ultra low sulphur diesel fuel, as described above, and is preferably unadditivated.

[0061] The driving cycles involve accumulation of engine miles, which may be under simulated conditions (such as using a chassis dynamometer) but preferably involve regular road driving, more preferably a mixture of driving conditions including both urban and motorway mileage.

[0062] The first number of miles should be sufficient to cause a significant loss in power compared to that measured in step 1 of the test. A typical first driving cycle might involve between 1000 and 4000 miles (1600 and 6400 km), preferably 1500 miles (2400 km) or more, more preferably 2000 (3200 km) or 3000 miles (4800 km) or more.

[0063] An appropriate number of miles for the second driving cycle is typically between 10 and 100%, preferably between 10 and 80%, more preferably between 10 and 60%, such as around 50%, of the first number of miles.

[0064] The engine used for the test is preferably of the rotary pump or common rail type, more preferably rotary pump. It is suitably a light duty diesel engine.

[0065] Particularly preferred is a Ford Endura™ engine, as used in the Ford Focus™ vehicle, such as the 1753 cc Ford Endura™ Di C9DC engine which has a Bosch™ VP-30 rotary distributor type fuel pump. Engines having mechanically actuated injectors are preferred.

[0066] Engine power may suitably be measured in the ways mentioned above in connection with the first aspect of the present invention. In particular, it may be assessed by measuring vehicle tractive effort (VTE) and/or acceleration times for the engine. A reduction in power corresponds to a reduction in VTE and/or an increase in acceleration times; power recovery corresponds to a recovery of (ie, increase in) VTE and acceleration rate, and therefore a reduction in acceleration times.

[0067] Such power measurements may be conducted using the standard fuel composition; conventional measurement procedures may be used. Ideally, acceleration times are measured under two or more, preferably three, different driving conditions (for instance, in 3rd, 4th and 5th gears) and the results averaged. Similarly, VTE measurements are preferably averaged over two or more, preferably three, different driving speeds, for instance at 50, 85 and 100 kilometres per hour (kph) in 4th gear. Acceleration time and VTE results may be combined and averaged to give an overall power rating.

[0068] Engine emissions (in particular smoke and particulate mass) may also be measured and compared before and after the first and second driving cycles. Again, conventional measurement procedures may be used, and run on the standard fuel composition. Smoke measurements are preferably averaged over two or more, preferably three, engine speeds, for example 70, 85 and 100 kph in 4th gear.

[0069] The assessment method of the present invention is particularly applicable to a candidate fuel composition which incorporates a detergent-containing additive, more particularly to an additivated low or ultra low sulphur fuel and/or to an additivated fuel containing a proportion (for instance, 10% v/v or more) of, reaction products of a Fischer-Tropsch methane condensation process such as the process known as Shell Middle Distillate Synthesis (SMDS). The method may therefore be used to identify and/or evaluate fuel compositions according to the fourth aspect of the present invention.

[0070] The method may also be used to assess the performance of a diesel engine, in particular a direct injection diesel engine, more particularly of the rotary pump type, and/or to assess the performance of a fuel injection system for use in a diesel engine, and/or to assess the performance of a vehicle driven by a diesel engine.

[0071] An ninth aspect of the present invention provides a diesel fuel composition which, when used as the candidate fuel composition in the assessment method of the seventh aspect of the present invention, causes at least a 25% recovery of the power lost during the first driving cycle, preferably a 50%, a 75%, a 90% or a 100% recovery, when the second number of miles is the same as or more preferably 75% or even 50% of the first number of miles, and the first number of miles is preferably at least 1500 (2400 km), more preferably 3000 (4800 km) or more.

[0072] Such a fuel composition ideally contains, in accordance with the present invention, a detergent-containing additive.

[0073] The present invention will be further understood from the following illustrative examples, which investigated the effects of using detergent-containing additives in diesel fuel compositions, on the performance of rotary pump direct injection diesel engines. Particular attention was paid to the fuel injectors, following a finding that power loss could be linked to injector fouling.

[0074] References to "dirty-up" vehicle tests are generally to the running of a vehicle using a typical unadditivated diesel fuel, expected to result in power loss. Such tests, unless otherwise stated, used mixed driving cycles, ie, road driving including both urban and motorway mileage, typically for 3000 miles (4800 km). References to "clean-up" vehicle tests are to the running of a vehicle, again typically using a mixed driving cycle, on a fuel in accordance with the present invention, expected to reduce and/or reverse power loss.

[0075] Power levels were assessed on the basis of (i) vehicle tractive effort (VTE), measured in 4th gear at 50, 85 and 100 kph and (ii) gated acceleration times in 3rd (30-80 kph), 4th (40-100 kph) and 5th (60-120 kph) gears. Where indicated, results were averaged over the three driving speeds.

[0076] All acceleration and power measurements, unless otherwise stated, were taken using a purpose built performance measurement chassis dynamometer, using the test protocol described below. Temperature, pressure and humidity were recorded at each measurement. All VTE measurements were NTP corrected (DIN 70020), ie, corrected to take account of variations in temperature and pressure. Acceleration time correction factors were not applied.

[0077] Where new injectors were fitted, 200 miles of conditioning were run prior to taking power measurements.

[0078] In some experiments, smoke and particulate emissions were also measured, using standard procedures as recorded in the relevant examples.

[0079] The type of engine used in all of the tests was a 1753 cc Ford Endura™ Di C9DC engine, which is a direct injection engine having a Bosch™ VP-30 rotary distributor type fuel pump chain driven from the crankshaft. It is a four cylinder (in-line configuration) engine which features turbocharging and after-cooling. The fuel injectors are of the slim five-hole type (pencil fuel injectors) located centrally over the piston recess. The injectors are mechanically actuated and operate at a fuel injection pressure of approximately 1100 bar (110 MPa). Fuel injection is electronically controlled.

[0080] The exhaust gas recirculation (EGR) system of the Endura™ engine recycles measured quantities of exhaust gas back through the engine where they mix with the incoming air charge, and incorporates an EGR cooler to cool the recirculated exhaust gas therefore lowering the combustion temperature and reducing the formation of nitrogen oxides.

[0081] Acceleration and Power Measurement Test Protocol

[0082] The vehicle is either mounted on a chassis dynamometer or driven under test track conditions. The vehicle and/or chassis dynamometer are initially warmed up over a suitable period of time in order to stabilise oil and coolant temperatures.

[0083] At each fuel change, the engine is flushed with an ULSD base fuel to ensure there is no cross-contamination between fuels. Also at each change, the vehicle is preconditioned with five consecutive accelerations (4th gear full throttle from 30 mph (48 kph) to 60 mph (96 kph)). Eight further consecutive accelerations are then carried out to allow the engine management system to adapt to the fuel and test conditions.

[0084] Vehicle acceleration times are measured between two chosen speeds. Data logging commences 2 kph below the chosen start point and finishes 2 kph above the end point. The engine is driven with a clean and progressive full throttle movement, keeping below 4500 rpm at all times, and full throttle is held until the end point has been exceeded. The vehicle is allowed to decelerate at the same rate that it accelerated, which is achieved using the foot brake, although normal unaided deceleration is allowed for the final 200 rpm. Three acceleration measurements are carried out for each test condition, and the results averaged.

[0085] Vehicle tractive effort (VTE) measurements are taken from the dynamometer, which measures power at the driven wheels, again using full throttle.

[0086] Acceleration times are reported to the nearest 0.01 second and constant speed VTE measurements to the nearest 0.01 kW.

EXAMPLES

Example 1

[0087] This demonstrates the ability of a detergent-containing additive to arrest, and also to reverse, power loss in a light duty direct injection diesel engine running on an ultra low sulphur diesel (ULSD) fuel.

[0088] The vehicle used was a Ford Focus™ equipped with an Endura™ engine, as described above. Its fuel injectors were new at the start of the experiment and were subjected to 3000 miles of "dirty-up" on an ULSD base fuel during step 1.

[0089] The base fuel, which contained no additives, had the following specification (Table A):

TABLE A

Property	Test method	
Density @ 15° C. (g/cm^3)	IP 365/ASTM D4052	0.8301
Distillation:	IP 123/ASTM D86	
IBP (° C.)		169.5
10%		204.0
20%		225.0
30%		244.0
40%		260.0
50%		273.5
60%		285.0
70%		297.0
80%		310.0
90%		328.0
95%		345.0
FBP		356.0
Cetane number	ASTM D613	54.5
Sulphur (ppmw)	ASTM D2622	54.5

[0090] Step 2 of the experiment involved a 1500 mile "clean-up", for which a detergent-containing additive A was added to the base fuel in accordance with the present invention. Additive A is a top-tier detergency additive available from Infineum (F7661) containing a polyisobutylene substituted succinimide detergent, an anti-foam agent, an anti-rust agent, a dehazer, EHN as an ignition improver, and a lubricity enhancer. It was added at a concentration of 1870 ppmw (double its standard treat rate); this results in an active matter detergent concentration of 162 ppmw in the additivated fuel.

[0091] Acceleration times and VTE were measured, using the base fuel, on the new injectors and at the end of each subsequent step. The results are shown in Table 1.

TABLE 1

Test condition	Average NTP corrected VTE (kW)	Average acceleration time (s)
Injectors as new	38.13	15.73
After 3000 mile (4800 km) dirty-up (step 1)	36.42	17.20
After 1500 mile (2400 km) clean-up (step 2)	38.74	15.68

[0092] A significant loss of power (as manifested by a reduction in VTE and a corresponding increase in acceleration times) was observed after running the engine on the base fuel alone. Following 1500 miles on the additivated fuel however, the lost power had been fully recovered. This demonstrates the ability of additive A to reverse the adverse effects of running on an unadditivated ULSD fuel.

[0093] The experiment then investigated the effect of using additive A at a lower concentration (935 ppmw, its "standard" treat rate). A different Ford Focus™ was used, but having the same type of engine and in particular injection system as the vehicle used for the first part of the test. The procedure was as follows, acceleration and VTE measurements again being taken, using the base fuel, after each step:

[0094] Step 3 3000 mile (4800 km) dirty-up on the base fuel.

[0095] Step 4 1500 mile (2400 km) clean-up (base fuel+additive A (935 ppmw)).

[0096] Step 5 Further 1500 mile (2400 km) dirty-up (base fuel).

[0097] The results are shown in Table 2.

TABLE 2

Test condition	Average NTP corrected VTE (kW)	Average acceleration time (s)
After 3000 mile (4800 km) dirty-up (step 3)	36.75	16.38
After 1500 mile (2400 km) clean-up with lower additive dose (step 4)	36.81	16.26
After 1500 mile (2400 km) dirty-up (step 5)	36.06	16.82

[0098] Again, dirty-up using the unadditivated fuel caused significant loss of power. Incorporation of additive A into the fuel, even at this lower dose, prevented further power loss. The inclusion of step 5 (further dirty-up) verifies that this effect is due to the presence of the additive rather than a peak in power loss having been attained—it can be seen that the further dirty-up results in yet further power losses.

[0099] Overall, the experiment revealed a power loss of approximately 5% after 3000 miles (4800 km) of dirty-up, with approximately 100% recovery following 1500 miles (2400 km) on the additivated fuel (higher dose). The further 3000 mile (4800 km) dirty-up resulted in another 5% power loss, to which there was no change during the 1500 miles (2400 km) on the lower dose additivated fuel. The final dirty-up resulted in approximately 6.9% total power loss.

[0100] Thus, the inclusion of additive A in the fuel can be seen to be of use in both maintaining engine power and, at higher concentrations, reversing previously incurred power losses.

Example 2

[0101] This also demonstrates power loss and recovery in a direct injection diesel engine.

[0102] A second hand Endura™ engined Ford Focus™ (different to that used in Example 1), which had run around 11,000 miles (17600 km), was fuelled with an unadditivated ULSD base fuel having the following properties (Table B):

TABLE B

Property	Test method	
Density @ 15° C. (g/cm^3)	IP 365/ASTM D4052	0.834
Distillation:	IP 123/ASTM D86	
IBP (° C.)		166.0
10%		209.5
20%		231.5
30%		253.5
40%		269.5
50%		281.5
60%		292.0
70%		302.0
80%		314.5
90%		331.5
95%		347.0
FBP		355.5
Cetane number	ASTM D613	54.6
Sulphur (ppmw)	ASTM D2622	45

[0103] The vehicle was serviced prior to starting the experiment. A new set of injectors was then fitted and conditioned and power measurements (acceleration times and VTE) recorded using the ULSD base fuel. A 1500 mile (2400 km) dirty-up was then carried out using the base fuel, followed by further power measurements.

[0104] The remaining procedure was as follows, each step being followed by acceleration and VTE measurements on the base fuel:

[0105] Step 1 Further 1500 mile (2400 km) dirty-up (base fuel).

[0106] Step 2 Fit and condition a new injector set.

[0107] Step 3 Replace old injector set; 1500 mile (2400 km) clean-up on (base fuel+1870 ppmw of additive A).

[0108] Step 4 1500 mile (2400 km) dirty-up (base fuel).

[0109] Step 5 Further 1500 mile (2400 km) dirty-up (base fuel).

[0110] Step 6 1500 (2400 km) mile clean-up (base fuel+1920 ppmw of additive A).

[0111] Steps 4 to 6 were included to demonstrate the repeatability of steps 1 to 3.

[0112] Miles were accumulated by normal evening and weekend driving, no journey involving exclusively motorway driving and the accumulation rate being no greater than 750 miles (1200 km) per week.

[0113] The VTE results are shown in Table 3 and the acceleration times in Table 4.

TABLE 3

Test condition	NTP corrected VTE (kg) at - 50 kph	85 kph	100 kph	Average power loss (%) relative to new injectors
After initial 1500 mile (2400 km) dirty-up	131.835	187.571	170.960	5.34
After further 1500 mile (2400 km) dirty-up (step 1)	122.609	185.956	169.609	7.69
New injectors (step 2)	138.411	196.422	183.192	0
Old injectors after 1500 mile (2400 km) clean-up (step 3)	140.824	195.533	176.283	1.04
After 1500 mile (2400 km) dirty-up (step 4)	126.500	190.800	175.500	4.87
After further 1500 mile (2400 km) dirty-up (step 5)	124.767	187.817	171.359	6.58
After 1500 mile (2400 km) clean-up (step 6)	134.179	201.268	183.448	0.17

[0114]

TABLE 4

Test condition	Acceleration time (s) in-3rd gear (30–80 kph)	4th gear (40–100 kph)	5th gear (60–120 kph)	Average increase in acceleration time (%) relative to new injectors
After initial 1500 mile (2400 km) dirty-up	9.13	18.23	24.40	10.77
After further 1500 mile (2400 km) dirty-up (step 1)	9.91	19.76	26.58	20.41
New injectors (step 2)	8.53	16.23	21.97	0
Old injectors after 1500 mile (2400 km) clean-up (step 3)	8.72	16.79	22.48	2.71
After 1500 mile (2400 km) dirty-up (step 4)	9.13	17.65	23.62	7.88

TABLE 4-continued

Test condition	Acceleration time (s) in- 3rd gear (30–80 kph)	4th gear (40–100 kph)	5th gear (60–120 kph)	Average increase in acceleration time (%) relative to new injectors
After further 1500 mile (2400 km) dirty-up (step 5)	8.93	18.43	25.24	12.61
After 1500 mile (2400 km) clean-up (step 6)	9.12	17.08	23.18	5.70

[0115] The base measurement for these results was taken as the value recorded after fitting the new injectors.

[0116] Both sets of results indicate a significant decrease in power (around 5% reduction in VTE and 8-10% increase in acceleration times) after 1500 miles (2400 km) on the ULSD base fuel, with a further increase on accumulating another 1500 miles (2400 km) (around 8% cumulative VTE loss and 11-20% cumulative increase in acceleration times). Following the 1500 mile (2400 km) clean-up (step 3), using an additivated fuel in accordance with the present invention, power appeared to have been recovered and VTE was no longer significantly different to that recorded for the clean injectors. Acceleration times returned to levels approaching (higher by between 2 and 6%) those achieved with the new injectors.

[0117] During steps 4 and 5 the earlier power losses were more or less repeated, the VTE losses being 5% after step 4 and 7% after step 5 (not significantly different to the results from steps 1 and 2). Again the additivated fuel yielded a full power recovery, VTE returning to a level comparable with that achieved using the new injectors.

Example 3

[0118] This demonstrates the use of alternative additivated fuel compositions in accordance with the present invention.

[0119] Two detergent-containing additives, B and C, were used. Additive B is an additive available from Infineum (F7685) which passes the Cummins L10 heavy duty detergency test and contains inter alia a detergent, an anti-foam agent and a corrosion inhibitor. Additive C is an additive available from Octel (OMA 4130D) of use for low sulphur fuels and contains a detergent, an anti-foam agent, an anti-rust agent and a dehazer.

[0120] Both additives were incorporated into the ULSD base fuel used in Example 1, at a concentration of 1042 ppmw for additive B and 500 ppmw for additive C. In both cases this represents double the "standard" treatment dose for the additive in question, and yields an active matter detergent concentration of greater than 100 ppmw in the additivated fuel.

[0121] The procedure was analogous to steps 1 and 2 of Example 1, although only VTE measurements were taken. New or cleaned injector sets were used at the start of each test. All tests were run on Ford Focus™ vehicles with Endura™ engines, as described above.

[0122] In the test using additive B, mileage accumulation was carried out using a mileage accumulation chassis dynamometer (MACD) (rolling road). Dirty-up mileage accumulation consisted of 72 hours on a light duty test cycle (representing approximately 3000 road miles (4800 km)); clean-up consisted of 36 hours (approximately 1500 road miles (2400 km)) on the same cycle. Each test cycle involved 300 seconds' steady running at an effective road speed of 37 mph (59 kph), followed by about 10 seconds' acceleration between 37 (59 kph) and 50 mph (80 kph), followed by about 50 seconds' steady running at 50 mph (80 kph) and then 90 seconds' idle.

[0123] In the test using additive C, miles were accumulated using a mixed driving cycle as in Example 1. Here, dirty-up and clean-up were run using two different vehicles, the second (clean-up) being that used in Example 1. Thus, in assessing the results, percentage changes in VTE from the beginning of each test point must be considered, rather than absolute values.

[0124] The results are shown in Tables 5 (additive B) and 6 (additive C).

TABLE 5

Test condition	NTP corrected VTE (kW) at - 50 kph	85 kph	100 kph
Pre dirty-up	18.53	43.95	48.18
Post dirty-up	15.51	41.67	45.66
Post clean-up	16.73	44.07	48.11

[0125]

TABLE 6

Test condition	NTP corrected VTE (kW) at - 50 kph	85 kph	100 kph
Pre dirty-up (vehicle 1)	19.18	47.47	51.04
Post dirty-up (vehicle 1)	16.63	44.43	47.22
Pre clean-up (vehicle 2)	14.99	42.45	46.35
Post clean-up (vehicle 2)	17.19	43.48	46.85

[0126] Averaged over the three test speeds, additive B gave approximately 80% power recovery, and additive C approximately 50%.

Example 4

[0127] This demonstrates how power recovery progresses during use of an additivated fuel in accordance with the present invention.

[0128] Using the Ford Focus™ used in Example 1, acceleration and VTE measurements were taken at the start, middle (after 750 miles (1200 km)) and end of a 1500 mile (2400 km) clean-up cycle using the Example 1 base fuel to which 1870 ppmw of additive A had been added. Having undergone the Example 1 procedure, the vehicle had already been subjected to 3000 miles (4800 km) of dirty-up on the base fuel, 1500 miles (2400 km) on (base fuel+935 ppmw additive A) and a further 1500 miles (2400 km) on the base fuel alone.

[0129] The power levels were compared with those for the new injectors, ie, prior to any dirty-up.

[0130] The VTE results are shown in Table 7.

TABLE 7

Test point	NTP corrected VTE (kW) at - 50 kph	85 kph	100 kph
Start of test	15.19	42.10	45.85
Middle of test (750 miles (1200 km))	15.66	43.69	48.12
End of test (1500 miles (2400 km))	16.33	44.62	48.33

[0131] The relative percentage gains in power, comparing the start and end of test results, were 7.5% at 50 kph, 6.0% at 85 kph and 5.4% at 100 kph. This averages to a 6.3% power recovery over the three test conditions. Power had not, however, been fully recovered after only 750 miles (1200 km).

[0132] The acceleration time results are shown in Table 8.

TABLE 8

Test point	Acceleration time (s) in - 3rd gear (30–80 kph)	4th gear (40–100 kph)	5th gear (60–120 kph)
Start of test	9.95	19.40	26.41
Middle of test (750 miles)	9.40	18.33	25.30
End of test (1500 miles)	9.16	17.97	24.38

[0133] Consistent with the increase in VTE during clean-up, the acceleration times in all gears were reduced. Comparing the start and end of test results, in 3rd gear an overall 8.0% reduction was observed, in 4th gear a 7.4% reduction and in 5th gear a 7.7% reduction. The average across the three test conditions was therefore a 7.7% reduction.

Example 5

[0134] This demonstrates an additional benefit of using an additivated fuel in accordance with the present invention.

[0135] Measurements of black smoke opacity, using a Celesco™ C107 opacimeter, were taken at the start and end of the Example 4 test. From the start of each VTE speed set point, 5 seconds of stabilisation were followed by logging of the opacimeter output for 10 seconds (output averaged). Measurements were recorded at 70, 85 and 100 kph, then the vehicle deccelerated back to idle for 5 minutes with a fan speed at 50 kph. This procedure was repeated twice more, giving three measurements at each of the test speeds. The fuel used for the smoke measurements was the Example 1 base fuel.

[0136] The results are shown in Table 9.

TABLE 9

Test point	Smoke opacity (%) at - 70 kph (90% confidence limits)	85 kph	100 kph
Start of test	4.292 (0.457)	5.201 (0.347)	7.976 (0.457)
End of test	3.724 (0.187)	5.027 (0.160)	6.659 (0.326)

[0137] The average reduction in smoke opacity over the three vehicle speeds was 15%, which is significant at a 90% confidence level. The reduction was particularly marked at 100 kph. This demonstrates that an additivated fuel composition in accordance with the present invention may yield environmental benefits, as well as the previously observed power recovery effect.

Example 6

[0138] This demonstrates the use of detergent-containing additives in alternative fuel compositions in accordance with the present invention.

[0139] The "base" fuel composition for these experiments had the following properties (Table C):

TABLE C

Property	Test method	
Density @ 15° C. (g/cm^3)	IP 365/ ASTM D4052	0.8377
C (% m/m)		86.3
H (% m/m)		13.7
N (% m/m)		<0.1
Calorific value (gross heat of combustion) (cal (IT)/g)		10945
Calorific value (net heat of combustion) (cal (IT)/g)		10251

[0140] It was used with a single dose (100 ppmw) of a commercially available lubricity additive PARADYNE™ 655 (ex Infineum).

[0141] A blend of this base fuel was also prepared with 15% v/v of a mixture of Shell Middle Distillate Synthesis (Fischer-Tropsch) reaction products having the following properties (Table D):

TABLE D

Property	Test method	
Density @ 15° C. (g/cm^3)	IP 365/ ASTM D4052	0.776
Distillation:	IP 123/ASTM D86	
IBP (° C.)		183.5
10%		214.1
20%		228.4
30%		243.6
40%		259.5
50%		275.4
60%		291.2
70%		306.9
80%		322.9
90%		340

TABLE D-continued

Property	Test method	
95%		351.3
FBP		359
Cetane number	ASTM D613	81
Sulphur (ppmw)	IP 373	0

[0142] It was to the blended fuel (overall density 0.830 g/cm^3) that additives A and B were added for subsequent testing.

[0143] The experimental procedure was as follows:

[0144] Step 1 Using the base fuel alone, record start-of-test (SOT) acceleration, VTE and smoke measurements, followed by particulate emission levels.

[0145] Step 2 Using the blended fuel, together with 1042 ppmw of additive B, record start-of-test acceleration, VTE and smoke measurements, followed by particulate emission levels.

[0146] Step 3 Using the blended fuel together with 1870 ppmw of additive A, record start-of-test acceleration, VTE and smoke measurements, followed by particulate emission levels.

[0147] Step 4 Remove the fuel lines and change to the ULSD base fuel of Example 1, but containing 1042 ppmw of additive B.

[0148] Step 5 "Clean-up" cycle—1500 miles (2400 km) of mixed driving using the fuel referred to in step 4.

[0149] Step 6 Refit auxiliary fuel lines and record acceleration and VTE measurements using the ULSD base fuel alone.

[0150] Step 7 Using the blended fuel together with 1042 ppmw of additive B, record end-of-test (ie, post clean-up, EOT) acceleration, VTE and smoke measurements, followed by particulate emission levels.

[0151] Step 8 Using the blended fuel together with 1870 ppmw of additive A, record end-of-test acceleration, VTE and smoke measurements, followed by particulate emission levels.

[0152] The same chassis dynamometer was used for the smoke as for the acceleration and VTE measurements. The procedure for the smoke measurements was as in Example 5.

[0153] Particulate emissions were tested using a chassis dynamometer. Testing used the standard ECE 1505(m) 11s 221 cycle, with sampling including cranking and start up emissions. A 40 second idle (Euro 2) was run prior to sampling. The cycle comprises four ECE cycles and one EUDC cycle with the results presented in a three phase format which includes the combined the first and second ECE cycles (cold engine), the combined third and fourth ECE cycles (hot engine) and the EUDC cycle. Particulate measurements were made for each phase. Results quoted below are for the full cycle.

[0154] The VTE results are shown in Table 10.

TABLE 10

Fuel composition	Average NTP corrected VTE (kW) - Start of test	End of test
ULSD base fuel	33.49	36.99
Example 6 base fuel	37.13	Not measured
Blended fuel + additive A	36.77	37.73
Blended fuel + additive C	36.67	37.59

[0155] Comparisons for the ULSD base fuel at the start and end of the tests appeared to indicate complete power recovery. Changing to the higher density Example 6 base fuel led to a significant, but predictable, increase in power compared to the ULSD base fuel (density of the ULSD base fuel=0.8301 g/cm^3, whereas that of the Example 6 base fuel=0.8377 g/cm^3).

[0156] The fuels containing additives A and B were of lower density than the Example 6 base fuel and as such predicted to cause reductions in power. Previous tests have indicated that a reduction in density of 3% leads to a lowering in VTE of between 5 and 8%. In contrast, the incorporation of additives A and B in this experiment, although it caused a density reduction of 0.9%, led to an average power reduction of only around 1%.

[0157] Both additivated fuels showed consistent trends between the start and end of test power measurements, VTE being increased in both cases by around 2.5% relative to the start of test measurements.

[0158] The acceleration time results showed directionally similar trends to those recorded for the VTE. Additive B gave an average reduction in acceleration times of 3% following clean-up, whilst additive A gave an average 11% reduction.

[0159] The Celesco black smoke measurements are shown in Table 11.

TABLE 11

Fuel composition	Smoke opacity (%) at - 70 kph (90% confidence limits)	85 kph	100 kph
Example 6 base fuel (SOT)	5.120 (0.194)	4.972 (0.223)	6.289 (0.726)
Blended fuel + additive A (SOT)	3.922 (0.716)	3.774 (0.223)	5.061 (0.303)
Blended fuel + additive A (EOT)	3.611 (0.797)	4.380 (0.621)	5.239 (0.223)
Blended fuel + additive C (SOT)	3.330 (0.254)	3.463 (0.438)	4.780 (0.129)
Blended fuel + additive C (EOT)	2.575 (0.084)	2.975 (0.223)	4.143 (0.702)

[0160] These results demonstrate that the increase in power associated with incorporation of additive A or B is accompanied by a reduction in smoke. The inclusion of additive A gave a significant (>90% confidence) reduction in smoke over the test period, at all three vehicle speeds.

[0161] The lower density blended fuel generally gave significantly lower (on average 20% across the three test phases) smoke levels, compared to the Example 6 base fuel.

[0162] The results of the particulate level measurements are shown in Table 12.

TABLE 12

Fuel composition	Particulate matter (g/km)
Example 7 base fuel	0.0464
Blended fuel + additive A (SOT)	0.046
Blended fuel + additive A (EOT)	0.043
Blended fuel + additive B (SOT)	0.043
Blended fuel + additive B (EOT)	0.041

[0163] A reduction in particulate mass was observed after the clean-up cycle. The Example 6 base fuel, as expected for a higher density fuel, produced higher particulate levels than the lower density blended fuels. However both additives A and B gave a consistent additional reduction in particulate levels of 6-7% after clean-up. These results indicate that the reductions in smoke and increases in power observed when using the detergent-containing additives A and B are the genuine results of engine clean-up rather than some form of artefact derived from the test conditions.

What is claimed is:

1. A diesel fuel composition which includes a major proportion of a fuel for an internal combustion engine of the compression ignition type, and a minor proportion of a detergent-containing additive, wherein the active matter detergent concentration in the composition is between 100 and 500 ppmw.

2. A diesel fuel composition according to claim 1, which contains reaction products of a Fischer-Tropsch methane condensation process.

3. The use of a detergent-containing fuel additive in a diesel fuel composition, for the purpose of reducing subsequent power loss in a diesel engine into which the fuel composition is introduced.

4. The use of a detergent-containing fuel additive in a diesel fuel composition, for the purpose of reversing a previously incurred power loss in a diesel engine into which the fuel composition is introduced.

5. The use of a detergent-containing fuel additive in a diesel fuel composition, for the purpose of reducing smoke and/or particulate emissions in a diesel engine into which the fuel composition is introduced.

6. The use according to claim 3, wherein the fuel composition contains reaction products of a Fischer-Tropsch methane condensation process.

7. A method of operating a diesel engine, and/or a vehicle which is driven by a diesel engine, which method involves introducing into the combustion chambers of the engine a diesel fuel composition according to claim 1.

8. A process for the preparation of a diesel fuel composition according to claim 1, which process involves admixing a major proportion of a diesel engine fuel with a minor proportion of a detergent-containing additive, the minor proportion being sufficient to give an active matter detergent concentration in the fuel composition of between 100 and 500 ppmw.

9. A method for assessing the performance of a candidate diesel fuel composition, comprising the steps of:

1) measuring power output for a diesel engine running on a standard diesel fuel composition, which standard fuel composition contains less than 50 ppmw active matter detergent;

2) subjecting the engine to a first driving cycle by running it for a first number of miles on the standard fuel composition;

3) measuring engine power after the first driving cycle;

4) calculating the reduction in engine power during the first driving cycle;

5) provided that significant power loss is observed during the first driving cycle, subjecting the engine to a second driving cycle by running it for a second number of miles on the candidate diesel fuel composition;

6) measuring engine power after the second driving cycle;

7) calculating the reduction in engine power (if any) during the second driving cycle; and

8) if applicable, calculating the extent of engine power recovery during the second driving cycle.

10. A method according to claim 9, wherein engine smoke and/or particulate emissions are also measured and compared before and after the first and second driving cycles.

* * * * *