

USE OF A DIESEL FUEL COMPOSITION

Field of the Invention

The present invention relates to the use of a diesel fuel composition comprising a biodiesel component for providing certain benefits in an Exhaust Gas Recirculation (EGR) system in a compression ignition engine. In particular, the present invention relates to the use of said diesel fuel composition for reducing the build-up of deposits in an Exhaust Gas Recirculation system in a compression ignition engine.

Background of the Invention

Exhaust Gas Recirculation (EGR) is a NO_x emission control technique applicable to a wide range of diesel engines from light-, medium- and heavy-duty diesel engines systems right up to two-stroke low-speed marine engines. The configuration of an EGR system depends on the required EGR rate and other demands of the particular application. Most EGR systems include the following main hardware components: one or more EGR control valves, one or more EGR coolers, piping, flanges and gaskets.

It has been found that EGR systems have a tendency to become fouled by deposits that build up on the various EGR hardware components. This is a particular problem with high pressure EGR systems. Deposits forming in the system can cause increased NO_x emissions and fuel consumption and can cause the system to fail by jamming the EGR valve or completing blocking the system in severe cases. Oxidation catalysts and/or particulate filters can be fitted before the EGR system to reduce hydrocarbons and particulates from the exhaust gas which cause EGR fouling, but this adds cost and complexity and

therefore isn't widely employed by manufacturers. In the case of low pressure EGR, the DPF is situated between the engine and the low pressure EGR system, therefore deposits are not such a problem in these configurations.

5 It would therefore be desirable to provide a fuel based solution that prevents the formation of deposits in the first instance, and is applicable to all EGR systems, irrespective of the equipment that the manufacturer has employed.

10 Biodiesel in the form of fatty acid methyl esters (FAME) is the most commonly used renewable fuel source in compression ignition (diesel) engines. FAMEs are typically derivable from biological sources and are typically included to reduce the environmental impact of
15 the fuel production and consumption process or to improve lubricity. Globally, there is a trend towards increasing levels of FAME in diesel fuel, though this is capped in some markets due to concerns around sustainability of FAME feedstocks and for reasons of engine/vehicle
20 compatibility.

 It has now been found that by using a diesel fuel composition comprising a certain amount of biodiesel component such as FAME, a surprising and hitherto
25 unrecognised reduction in the build-up of EGR deposits can be achieved.

Summary of the Invention

 According to the present invention there is provided the use of a diesel fuel composition comprising 5 vol% or greater of biodiesel for reducing the build-up of
30 deposits in an Exhaust Gas Recirculation (EGR) system of a compression ignition internal combustion engine.

 According to another aspect of the present invention there is provided a method for reducing the build-up of

deposits in an Exhaust Gas Recirculation (EGR) system of a compression ignition internal combustion engine, which method comprises a step of introducing into said engine a diesel fuel composition which comprises 5 vol% or greater of biodiesel.

It has been found that use of a diesel fuel composition comprising a certain amount of biodiesel component can provide reduced build-up of deposits in the EGR system of a compression ignition internal combustion engine.

It has also been found that use of a diesel fuel composition comprising a certain amount of biodiesel component can prevent the formation of deposits in the EGR system in the first place and is applicable to all EGR systems, irrespective of the equipment that the manufacturer has employed.

Brief Description of the Drawings

Figure 1 is a graphical representation of the EGR deposit mass results set out in Table 2 below with circular markers denoting individual test results and diamond markers denoting mean results for each FAME fuel content level tested in Example 1.

Figure 2 is a graphical representation of the mean EGR deposit mass results set out in Table 2 below for each FAME fuel content level tested in Example 1.

Figure 3 is a graphical representation of the mean percentage reduction in EGR deposit mass set out in Table 2 below for each FAME level tested in Example 1 versus B0.

Detailed Description of the Invention

As used herein there is provided the use of a diesel fuel composition comprising 5 vol% or greater of biodiesel for reducing the build-up of deposits in an

Exhaust Gas Recirculation (EGR) system of a compression ignition internal combustion engine.

In the context of this aspect of the invention, the term "reducing the build-up of deposits" embraces any
5 degree of reduction in the build-up of deposits. The reduction in the build-up of deposits may be of the order of 5% or more, preferably 10% or more, more preferably 20% or more, even more preferably 50% or more, and especially 70% or more compared to the build-up of
10 deposits in an EGR system caused by an analogous fuel formulation which does not contain a biodiesel component. As used herein, the term "reducing the build-up" also encompasses the prevention of EGR deposit formation in the first place.

15 It has been found that the present invention is particularly useful in the case of high pressure EGR systems because these systems are more susceptible to deposit build up than low pressure EGR systems.

It is also envisaged that the present invention may
20 be used for the purpose of clean-up of existing EGR deposits formed with conventional diesel fuel.

A first essential component herein is a biodiesel component. Biodiesel fuels are fuels which derive from biological materials.

25 The biodiesel component is present in the diesel fuel composition herein at a level of 5 %v/v or greater, preferably 10% v/v or greater, more preferably in the range from 10% v/v to 50% v/v, even more preferably in the range from 10% v/v to 40% v/v, and especially from 20% v/v
30 to 40% v/v. In an especially preferred embodiment of the present invention, the biodiesel component is present at a level in the range from 20% v/v to 30% v/v, based on the total diesel fuel composition.

Suitable biodiesel fuels for use herein include any bio-derived oxygenate. Processing routes exist to derive a variety of classes of oxygenates from biomaterial, these include alcohols, ketones, phenols, ethers and esters, such as alkyl esters, including, but not limited to methyl and ethyl esters.

A preferred biodiesel component for use herein is a fatty acid alkyl ester (FAAE). It is known to include fatty acid alkyl esters (FAAEs), in particular fatty acid methyl esters (FAMES), in diesel fuel compositions, although not in the context of reducing build-up of deposits in EGR systems. Examples of suitable FAAEs include rapeseed methyl ester (RME), palm oil methyl ester (POME), soy methyl ester, sunflower oil methyl ester, tallow methyl ester (TME), used cooking oil methyl ester (UCOME), and the like. FAAEs are typically derivable from biological sources and are typically included to reduce the environmental impact of the fuel production and consumption process or to improve lubricity.

FAAEs, of which the most commonly used in the context of diesel fuels are the methyl esters, are already known as renewable diesel fuels (so-called 'biodiesel' fuels). They contain long chain carboxylic acid molecules (generally from 10 to 22 carbon atoms long), each having an alcohol molecule attached to one end. Organically derived oils such as vegetable oils (including recycled vegetable oils) and animal fats (including fish oils) can be subjected to a transesterification process with an alcohol (typically a C₁ to C₅ alcohol) to form the corresponding fatty esters, typically mono-alkylated. This process, which is suitably either acid- or base-catalysed, such as with the base KOH, converts the triglycerides contained in the oils into fatty acid

components of the oils from their glycerol backbone.

FAAEs can also be prepared from used cooking oils, and can be prepared by standard esterification from fatty acids.

In the present invention, the FAAE may be any
5 alkylated fatty acid or mixture of fatty acids. Its fatty acid component(s) are preferably derived from a biological source, more preferably a vegetable source. They may be saturated or unsaturated. They may be linear or branched, cyclic or polycyclic. Suitably, they will have from 6 to
10 30, preferably 10 to 30, more suitably from 10 to 22 or from 12 to 24 or from 16 to 18, carbon atoms including the acid group(s) $-CO_2H$. A FAAE will typically comprise a mixture of different fatty acid esters of different fatty acid esters of different chain lengths, depending on its
15 source.

The FAAE used in the present invention is preferably derived from a natural fatty oil, for instance tall oil, rapeseed oil, palm oil or soy oil.

The FAAE is preferably a C_1 to C_5 alkyl ester, more
20 preferably a methyl, ethyl, propyl, (suitably iso-propyl) or butyl ester, yet more preferably a methyl or ethyl ester and in particular a methyl ester. In one embodiment herein, the FAAE is selected from methyl ester of palm oil (POME) and methyl ester of rapeseed oil (RME, and mixtures
25 thereof.

In general, it may be either natural or synthetic, refined or unrefined ('crude').

The FAAE may contain impurities or by-products as a result of the manufacturing process.

30 The FAAE suitably complies with specifications applying to the rest of the fuel composition, and/or to the base fuel to which it is added, bearing in mind the intended use to which the composition is to be put (for

example, in which geographical area and at what time of year). In particular, the FAAE preferably has a flash point (IP 34) of greater than 101°C; a kinematic viscosity at 40°C (IP 71) of 1.9 to 6.0 mm²/s, preferably 3.5 to 5.0 mm²/s; a density of 845 to 910 kg/m³, preferably from 860 to 900 kg/m³, at 15°C (IP 365, EN ISO 12185 or EN ISO 3675); a water content (IP 386) of less than 500 ppm; a T95 (the temperature at which 95% of the fuel has evaporated, measured according to IP 123) of less than 360°C; an acid number (IP 139) of less than 0.8mgKOH/g, preferably less than 0.5mgKOH/g; and an iodine number (IP 84) of less than 125, preferably less than 120 or less than 115, grams of iodine (I₂) per 110g of fuel. It also preferably contains (e.g. by gas chromatography (GC)) less than 0.2% w/w of free methanol, less than 0.02% w/w of free glycerol and greater than 96.5% w/w esters. In general it may be preferred for the FAAE to conform to the European specification EN14214 for fatty methyl esters for use as diesel fuels.

Two or more FAAEs may be added to the diesel fuel composition in accordance with the present invention, either separately or as a pre-prepared blend.

The FAAE is incorporated into the diesel fuel composition typically as a blend (i.e. a physical mixture) and optionally with one or more other fuel components (such as diesel base fuels) and optionally with one or more fuel additives. The FAAE is conveniently incorporated into the diesel fuel composition before the composition is introduced into the diesel engine which is to be run on the fuel composition.

A preferred fuel component for use in the diesel fuel composition herein, in addition to the FAAE, is a paraffinic gasoil. The paraffinic gasoil suitable for use

in the present invention can be derived from any suitable source as long as it is suitable for use in a diesel fuel composition.

5 Suitable paraffinic gasoils include, for example, Fischer-Tropsch derived gasoils, and gasoils derived from hydrotreated vegetable oil (HVO), and mixtures thereof.

10 A preferred paraffinic gasoil for use herein is a Fischer-Tropsch derived gasoil fuel. The paraffinic nature of Fischer-Tropsch derived gasoil means that diesel fuel compositions containing it will have high cetane numbers compared to conventional diesel.

15 While Fischer-Tropsch derived gasoil is a preferred paraffinic gasoil for use herein, the term "paraffinic gasoil" as used herein also includes those paraffinic gasoils derived from the hydrotreating of vegetable oils (HVO). The HVO process is based on an oil refining technology. In the process, hydrogen is used to remove oxygen from the triglyceride vegetable oil molecules and to split the triglyceride into three separate chains thus
20 creating paraffinic hydrocarbons.

25 When present, the paraffinic gasoil (i.e. the Fischer-Tropsch derived gasoil, the hydrogenated vegetable oil derived gasoil) will preferably consist of at least 95% w/w, more preferably at least 98% w/w, even more preferably at least 99.5% w/w, and most preferably up to 100% w/w of paraffinic components, preferably iso- and normal paraffins.

30 By "Fischer-Tropsch derived" is meant that a fuel or base oil is, or derives from, a synthesis product of a Fischer-Tropsch condensation process. The term "non-Fischer-Tropsch derived" may be interpreted accordingly. A Fischer-Tropsch derived fuel may also be referred to as a GTL (gas-to-liquid) fuel.

The Fischer-Tropsch reaction converts carbon monoxide and hydrogen into longer chain, usually paraffinic, hydrocarbons:

$$n(\text{CO} + 2\text{H}_2) = (-\text{CH}_2-)_n + n\text{H}_2\text{O} + \text{heat}$$
in the presence of an appropriate catalyst and typically at elevated temperatures (e.g. 125 to 300°C, preferably 175 to 250°C) and/or pressures (e.g. 5 to 100 bar, preferably 12 to 50 bar). Hydrogen: carbon monoxide ratios other than 2:1 may be employed if desired.

The carbon monoxide and hydrogen may themselves be derived from organic or inorganic, natural or synthetic sources, typically either from natural gas or from organically derived methane. More recently routes to derive this syngas carbon monoxide from carbon dioxide are being tried in order to obtain greenhouse gas benefits.

Gas oil, kerosene fuel and base oil products may be obtained directly from the Fischer-Tropsch reaction, or indirectly for instance by fractionation of Fischer-Tropsch synthesis products or from hydrotreated Fischer-Tropsch synthesis products. Hydrotreatment can involve hydrocracking to adjust the boiling range (see, e. g. GB2077289 and EP0147873) and/or hydroisomerisation which can improve cold flow properties by increasing the proportion of branched paraffins. EP0583836 describes a two-step hydrotreatment process in which a Fischer-Tropsch synthesis product is firstly subjected to hydroconversion under conditions such that it undergoes substantially no isomerisation or hydrocracking (this hydrogenates the olefinic and oxygen-containing components), and then at least part of the resultant product is hydroconverted under conditions such that hydrocracking and isomerisation occur to yield a

substantially paraffinic hydrocarbon fuel or oil.
Desired diesel fuel fraction(s) may subsequently be
isolated for instance by distillation.

Other post-synthesis treatments, such as
5 polymerisation, alkylation, distillation, cracking-
decarboxylation, isomerisation and hydroreforming, may be
employed to modify the properties of Fischer-Tropsch
condensation products, as described for instance in US-A-
4125566 and US-A-4478955.

10 Typical catalysts for the Fischer-Tropsch synthesis
of paraffinic hydrocarbons comprise, as the catalytically
active component, a metal from Group VIII of the periodic
table, in particular ruthenium, iron, cobalt or nickel.
Suitable such catalysts are described for instance in
15 EP0583836.

An example of a Fischer-Tropsch based process is the
SMDS (Shell Middle Distillate Synthesis) described in
"The Shell Middle Distillate Synthesis Process", van der
Burg et al (vide supra). This process (also sometimes
20 referred to as the Shell "Gas-to-Liquids" or "GTL"
technology) produces diesel range products by conversion
of a natural gas (primarily methane) derived synthesis
gas into a heavy long-chain hydrocarbon (paraffin) wax
which can then be hydroconverted and fractionated to
25 produce liquid transport fuels such as gasoils and
kerosene. Versions of the SMDS process, utilising fixed-
bed reactors for the catalytic conversion step, are
currently in use in Bintulu, Malaysia, and in Pearl GTL,
Ras Laffan, Qatar. Kerosenes and (gas)oils prepared by
30 the SMDS process are commercially available for instance
from the Royal Dutch/Shell Group of Companies.

By virtue of the Fischer-Tropsch process, a Fischer-
Tropsch derived gasoil has essentially no, or

undetectable levels of, sulphur and nitrogen. Compounds containing these heteroatoms tend to act as poisons for Fischer-Tropsch catalysts and are therefore removed from the synthesis gas feed. Further, the process as usually operated produces no or virtually no aromatic components.

For example, the aromatics content of a Fischer-Tropsch gasoil, as determined for instance by ASTM D4629, will typically be below 1% w/w, preferably below 0.5% w/w and more preferably below 0.1% w/w.

Generally speaking, Fischer-Tropsch derived fuels have relatively low levels of polar components, in particular polar surfactants, for instance compared to petroleum derived fuels. It is believed that this can contribute to improved antifoaming and dehazing performance. Such polar components may include for example oxygenates, and sulphur and nitrogen containing compounds. A low level of sulphur in a Fischer-Tropsch derived fuel is generally indicative of low levels of both oxygenates and nitrogen-containing compounds, since all are removed by the same treatment processes.

A preferred Fischer-Tropsch derived gasoil fuel for use herein is a liquid hydrocarbon middle distillate fuel with a distillation range similar to that of a petroleum derived diesel, that is typically within the 160°C to 400°C range, preferably with a T95 of 360°C or less. Again, Fischer-Tropsch derived fuels tend to be low in undesirable fuel components such as sulphur, nitrogen and aromatics.

A preferred Fischer-Tropsch derived gasoil fuel will typically have a density (as measured by EN ISO 12185) of from 0.76 to 0.80, preferably from 0.77 to 0.79, more preferably from 0.775 to 0.785 g/cm³ at 15°C.

A preferred Fischer-Tropsch derived gasoil fuel for

use herein has a cetane number (ASTM D613) of greater than 70, suitably from 70 to 85, most suitably from 70 to 77.

5 A preferred Fischer-Tropsch derived gasoil fuel for use herein has a kinematic viscosity at 40°C (as measured according to ASTM D445) in the range from 2.0 mm²/s to 5.0 mm²/s, preferably from 2.5 mm²/s to 4.0 mm²/s.

10 A preferred Fischer-Tropsch derived gasoil for use herein has a sulphur content (ASTM D2622) of 5 ppmw (parts per million by weight) or less, preferably of 2 ppmw or less.

15 A preferred Fischer-Tropsch derived gasoil fuel for use in the present invention is that produced as a distinct finished product, that is suitable for sale and used in applications that require the particular characteristics of a gasoil fuel. In particular, it exhibits a distillation range falling within the range normally relating to Fischer-Tropsch derived gasoil fuels, as set out above.

20 A fuel composition used in the present invention may include a mixture of two or more Fisher-Tropsch derived gasoil fuels.

25 When present, the Fischer-Tropsch derived components used herein (i.e. the Fischer-Tropsch derived gasoil) will preferably comprise no more than 3% w/w, more preferably no more than 2% w/w, even more preferably no more than 1% w/w of cycloparaffins (naphthenes), by weight of the Fischer-Tropsch derived component.

30 When present, the Fischer-Tropsch derived components used herein (i.e. the Fischer-Tropsch derived gasoil) preferably comprise no more than 1% w/w, more preferably no more than 0.5% w/w, of olefins, by weight of the Fischer-Tropsch derived component.

The diesel fuel compositions described herein for use in the present invention are particularly suitable for use as a diesel fuel, and can be used for arctic applications, as winter grade diesel fuel due to the excellent cold flow properties.

For example, a cloud point of -10°C or lower (EN 23015) or a cold filter plugging point (CFPP) of -20°C or lower (as measured by EN 116) may be possible with fuel compositions herein.

The diesel fuel compositions described herein may comprise a diesel base fuel in addition to a biodiesel fuel component.

The diesel base fuel may be any petroleum derived diesel suitable for use in an internal combustion engine, such as a petroleum derived low sulphur diesel comprising <50 ppm of sulphur, for example, an ultra-low sulphur diesel (ULSD) or a zero sulphur diesel (ZSD). Preferably, the low sulphur diesel comprises <10 ppm of sulphur.

The petroleum derived low sulphur diesel preferred for use in the present invention will typically have a density from 0.78 to 0.865, preferably from 0.80 to 0.845 g/cm^3 , at 15°C ; a cetane number (ASTM D613) at least 51; and a kinematic viscosity (ASTM D445) from 1.5 to 4.5, preferably 2.0 to 4.0, more preferably from 2.2 to 3.7 mm^2/s at 40°C .

In one embodiment, the diesel base fuel is a conventional petroleum-derived diesel.

Generally speaking, in the context of the present invention the fuel composition may be additivated with fuel additives.

It has been found by the present inventors that it is particularly advantageous to include a deposit control

additive (DCA) package in the diesel fuel composition in addition to the biodiesel component from the viewpoint of reducing build-up of deposits in the EGR system.

Unless otherwise stated, the (active matter)
5 concentration of each such additive in a fuel composition is preferably up to 10000 ppmw, more preferably in the range from 5 to 1000 ppmw, advantageously from 75 to 300 ppmw, such as from 95 to 150 ppmw. Such additives may be added at various stages during the production of a fuel
10 composition; those added to a base fuel at the refinery for example might be selected from anti-static agents, pipeline drag reducers, middle distillate flow improvers (MDFI) (e.g., ethylene/vinyl acetate copolymers or acrylate/maleic anhydride copolymers), lubricity
15 enhancers, anti-oxidants and wax anti-settling agents.

The fuel composition may include a DCA, 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 an engine, in particular in the
20 fuel injection system such as in the injector nozzles. Such materials are sometimes referred to as dispersant additives. Where the fuel composition includes a DCA, preferred concentrations are in the range 20 to 500 ppmw active matter detergent based on the overall fuel
25 composition, more preferably 40 to 500 ppmw, most preferably 40 to 300 ppmw or 100 to 300 ppmw or 150 to 300 ppmw. DCAs for diesel fuel are known and commercially available. Examples of suitable DCA
30 additives include polyolefin substituted succinimides or succinamides of polyamines, for instance polyisobutylene succinimides or polyisobutylene amine succinamides, aliphatic amines, Mannich bases or amines and polyolefin (e.g. polyisobutylene) maleic anhydrides. Particularly

preferred are polyolefin substituted succinimides such as polyisobutylene succinimides.

Other components which may be incorporated as fuel additives, for instance in combination with a detergent, include lubricity enhancers; dehazers, e.g. alkoxyated phenol formaldehyde polymers; anti-foaming agents (e.g. commercially available polyether-modified polysiloxanes); ignition improvers (cetane improvers) (e.g. 2-ethylhexyl nitrate (EHN), cyclohexyl nitrate, di-tert-butyl peroxide and those disclosed in US4208190 at column 2, line 27 to column 3, line 21); anti-rust agents (e.g. 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, e.g. the pentaerythritol diester of polyisobutylene-substituted succinic acid); corrosion inhibitors; reodorants; anti-wear additives; anti-oxidants (e.g. phenolics such as 2,6-di-tert-butylphenol, or phenylenediamines such as N,N'-di-sec-butyl-p-phenylenediamine); metal deactivators; static dissipator additives; and mixtures thereof.

It is 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.

It is particularly preferred that a lubricity enhancer be included in the fuel composition, especially when it has a low (e.g. 500 ppmw or less) sulfur content. The lubricity enhancer is conveniently present at a concentration from 50 to 1000 ppmw, preferably from 100 to 1000 ppmw, based on the overall fuel composition.

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) concentration of any ignition improver present will preferably be 600 ppmw or less, more preferably 500 ppmw or less, conveniently from 300 to 500 ppmw.

The present invention may in particular be applicable where the fuel composition is used or intended to be used in a direct injection diesel engine, for example of the rotary pump, in-line pump, unit pump, electronic unit injector or common rail type, or in an indirect injection diesel engine. The fuel composition may be suitable for use in heavy-and/or light-duty diesel engines, and in engines designed for on-road use or off-road use.

In order to be suitable for at least the above uses, the diesel fuel composition of the present invention preferably has one or more of the following characteristics:

- a kinematic viscosity at 40°C of 1.9 mm²/s or greater, more preferably in the range from 1.9 to 4.5 mm²/s;
- a density of 800 kg/m³ or greater, more preferably in the range from 800 to 860, even more preferably 800 to 845 kg/m³;
- a T95 of 360°C or less;
- a cloud point in the range from 0°C to -13°C, more preferably from -5°C to -8°C;
- a CFPP in the range of from -8°C to -30°C, more preferably from -15°C to -20°C.

The invention is illustrated by the following non-limiting examples.

ExamplesExample 1

Four different fuels were used in the examples herein.

5 One fuel was a conventional diesel fuel, CEC RF79-07 (Diesel B0). The physical characteristics of the conventional diesel fuel (Diesel B0) used in the examples is shown in Table 1 below. As used herein "Diesel B0" means diesel base fuel containing zero biofuel
10 components. The biofuel component was Palm Oil Methyl Ester - POME.

 The second, third and fourth test fuels were diesel fuel compositions designed to contain 10, 20, or 30% biofuel component. In fact, with normal experimental
15 errors, the actual bio-contents of the fuels were 10.5, 20.6 and 29.9%, respectively. The base diesel fuel to which the biofuel was added was diesel fuel complying with the EN590 diesel fuel specification and is a reference fuel designated CEC RF79-07. Again, the
20 biofuel component was a POME FAME component. The analysed properties of the diesel and FAME blends B10, B20, B30 fuel used in the examples is shown in Table 1 below.

Table 1: Test Fuel Parameter Measurements and Test Methods

Test Parameter	Test Method	Unit	Result - B0	Result - B10	Result - B20	Result - B30
Appearance	Visual		C&B	C&B	C&B	C&B
Cetane Number	EN ISO 5165		53.1	53.6	54.1	55.8
Cetane Index	EN ISO 4264			55.1	54.9	54.8
Density @ 15°C	EN ISO 12185	Kg/L	835.1	839.0	842.8	846.9
Cloud Point	EN ISO 23015	°C		-12	-4	0
CFPP	EN 116	°C	-22	-16	-6	-1
Carbon Residue (10% Dis. Res.)	EN ISO 10370	% m/m	<0.10			
Flash Point	EN ISO 2719	°C	88.0	88.0	90.0	93.0
Lubricity, wear scar diameter @ 60°C	EN ISO 12156-1	µm	324	191	184	191
Sulfur	EN ISO 20846	mg/kg	<1.0	<5	<5	<5
Viscosity @ 40°C	EN ISO 3104	mm ² /s	2.875	2.991	3.098	3.237
Water Content	EN ISO 12937	mg/kg	30	113	117	111
FAME Content	EN 14078	%v/v	0	10.5	20.6	29.9
Mono Aromatics Content	IP 391 mod	%m/m	18.1	16.2	14.1	12.2
Polycyclic Aromatics Content	IP 391 mod	%m/m	4.2	3.9	3.4	3.0
Total Aromatics	IP 391 mod	%m/m	22.3	20.1	17.5	15.2
Oxidation Stability	EN 15751	H		48.0	36.5	30.0
Oxidation Stability (16h)	EN ISO 12205	g/m ³	<1	1	1	1
Ash Content	EN ISO 6245	%m/m	<0.001	<0.001	<0.001	<0.001
Copper Corrosion (3h at 50°C)	EN ISO 2160	Rating	1A	1A	1A	1A
Total Contamination	EN 12662	Mg/kg		3	2	2

Carbon	ASTM D3343 mod	%m/m	86.36			
Hydrogen	ASTM D3343 mod	%m/m	13.64			
Oxygen	EN 14078	%m/m	0			
Gross Calorific Value	ASTM D3338 mod	MJ/kg				
Net Calorific Value	ASTM D3338	MJ/kg	43.18			
Distillation (Evaporated)						
E250	EN ISO 3405	%v/v		26.8	21.8	17.9
E350	EN ISO 3405	%v/v		97.5		
IBP	EN ISO 3405	°C	203.2	206.0	201.1	206.0
95%v	EN ISO 3405	°C	347.8	345.1	336.5	339.7
FBP	EN ISO 3405	°C	362.8	352.5	347.0	345.5

Test Method

The engine used in the examples was a standard configuration PSA DV6 1.6L Euro 5 engine of a type installed in several light-duty passenger car models in Europe. A clean EGR system was weighed, then fitted to the engine.

The test was run for 24 hours continuously, at 2500 rpm and 5kW (19Nm) test condition. The engine coolant temperature was controlled to 37°C for the entire test duration. When the test was completed, the engine was dismantled, and all EGR components weighed. All EGR components were then photographed, before the entire EGR system was cleaned using solvents and a sonic bath, to remove the deposits. The clean EGR system was then reweighed before being fitted to the engine to run the next test. A sequence of tests was run which was designed to avoid back to back repeats on any fuel, except for two tests on B0 at the start of the sequence which were run to ensure an acceptable level of repeatability. The remaining repeats on each fuel were distributed throughout the test sequence to result in a balanced test order. Four tests were run with B0 fuel and two tests on each of B10, B20 and B30. The test sequence and EGR deposit mass results are given in Table 2 below and the results are displayed in Figures 1-3.

Table 2: Fuel Testing Sequence and EGR Deposit MassResults

Test #	Test Fuel	EGR Deposit Mass (grams)
1	B0	18.53
2	B0	19.03
3	B20	13.56
4	B30	13.01
5	B10	14.12
6	B0	18.36
7	B10	15.32

8	B20	13.91
9	B30	13.84
10	B0	19.55
Mean result	B0	18.87
Mean result	B10	14.72
Mean result	B20	13.73
Mean result	B30	13.42
		Mean reduction relative to B0 (%)
Mean reduction	B10	22.0
Mean reduction	B20	27.2
Mean reduction	B30	28.8

Discussion

As can be seen from the results in Table 2 and the graphs in Figures 1-3, there is a significant reduction in the amount of deposits formed on the EGR components in the case of the FAME-containing fuels compared with the conventional diesel B0 fuel and the reduction increases with increasing FAME level. A 22.0% lower deposit mass formed on the EGR components in the case of B10 diesel fuel compared with the B0 diesel fuel. In the case of the B20 fuel the difference from B0 was 27.2% and in the case of the B30 fuel the difference from B0 was 28.8%.

C L A I M S

1. Use of a diesel fuel composition comprising 5 vol% or greater of biodiesel for reducing the build-up of deposits in an Exhaust Gas Recirculation (EGR) system of a compression ignition internal combustion engine.
- 5 2. Use according to Claim 1 wherein the diesel fuel composition comprises from 10 vol% to 50 vol% of biodiesel, based on the diesel fuel composition.
3. Use according to Claim 1 or 2 wherein the diesel fuel composition comprises from 20 vol% to 40 vol% of
10 biodiesel, based on the diesel fuel composition.
4. Use according to any of Claims 1 to 3 wherein the biodiesel is selected from a fatty acid alkyl ester.
5. Use according to any of Claims 1 to 4 wherein the biodiesel is fatty acid methyl ester.
- 15 6. Use according to any of Claims 1 to 5 wherein the biodiesel is rapeseed methyl ester (RME), palm oil methyl ester (POME), soy methyl ester, sunflower oil methyl ester, tallow methyl ester (TME), used cooking oil methyl ester (UCOME), and mixtures thereof.
- 20 7. Use according to any of Claims 1 to 6 wherein the diesel fuel composition additionally comprises a deposit control additive (DCA) additive package.
8. Use according to any of Claims 1 to 7 wherein the diesel fuel composition additionally comprises a diesel
25 base fuel.
9. Use according to any of Claims 1 to 8 wherein the diesel fuel composition additionally comprises a paraffinic base fuel selected from hydrotreated vegetable oil, Fischer-Tropsch derived base fuels, and mixtures
30 thereof.

10. Method for reducing the build-up of deposits in an Exhaust Gas Recirculation (EGR) system of a compression ignition internal combustion engine, which method comprises a step of introducing into said engine a diesel
5 fuel composition which comprises 5 vol% or greater of biodiesel.