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(54) **HIGH POWER FUEL COMPOSITIONS**

HOCHLEISTUNGSBRENNSTOFFZUSAMMENSETZUNGEN

COMPOSITIONS DE COMBUSTIBLE HAUTE PUISSANCE

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EP 3 022 278 B1

Description

Field of the invention

[0001] The present invention relates high power fuel compositions prepared by blending a petroleum derived low sulphur diesel with a Fischer-Tropsch (GTL) derived gasoil and a Fischer-Tropsch (GTL) derived base oil, and to the use of a Fischer-Tropsch derived base oil in said fuel compositions.

Background of the invention

[0002] It is well known that an increase in the viscosity of a fuel can increase the power performance of certain engines through the influence on the injection process. The principal mechanism leading to the power increase is reduced 'leakback' in the fuel injectors, i.e. with a high viscosity fuel the injected volume increases and hence there is a power benefit. However, generally, increasing fuel viscosity also increases fuel density, which can increase smoke emissions as the air/fuel ratio decreases. It is also known that there generally is a linear relationship between the density of a crude-oil derived fuel and its viscosity. WO2005/054411 describes that the density-viscosity correlation of a composition may be disrupted by incorporating a viscosity increasing component in a diesel fuel composition. The document exemplifies the use of oils having a kinematic viscosity (ASTM D445) of at least 15.26 mm^2/s at 40°C.

[0003] High viscosity fuels can be formulated by blending high viscosity components such as disclosed in WO2005/054411 into conventional diesel. However, there is a limit on how much can be blended whilst adhering to limits on certain properties (distillation, density) in diesel fuel specifications (e.g. EN 590). Additionally, the high viscosity components also increase the density of the fuel, and thus can be detrimental in terms of smoke emissions (as found in WO2005/054411). According to WO2005/054411, this is overcome by the addition of a third low density component, which is required to maintain the emissions performance of the high viscosity fuel.

[0004] The present invention relates to fuel compositions with increased power performance while still complying with the geographically relevant diesel fuel specification (e.g. EN 590). Moreover, unlike WO2005/054411, the viscosity increasing components in this present invention do not increase the density of the formulation and so there is no detriment to the emissions performance compared to conventional diesel.

Summary of the invention

[0005] According to the present invention new fuel compositions have been found comprising a low sulphur petroleum derived diesel component and a Fischer-Tropsch derived gas oil component, further comprising a high viscosity low density Fischer-Tropsch derived base oil component (e.g. GTL Baseoil 3), which fuel compositions display increased power performance when compared to conventional diesel, with no detriment to emissions performance.

[0006] Thus, an embodiment of the present invention is a fuel composition prepared by blending a petroleum derived low sulphur diesel comprising <50 ppm of sulphur with a Fischer-Tropsch derived gasoil and a Fischer-Tropsch derived base oil wherein the amount of the petroleum derived low sulphur diesel is from 60% up to 80% v/v of the total composition; the amount of Fischer-Tropsch derived gasoil is from 10% up to 30% v/v of the total composition; the amount of Fischer-Tropsch derived base oil is from 10% up to 30% v/v of the total composition; the amounts of the Fischer-Tropsch derived gas oil and Fischer-Tropsch derived base oil together being at least 20% v/v of the total composition; and wherein the petroleum derived low sulphur diesel has a density of 0.81 to 0.865 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 1.5 to 4.5 mm^2/s at 40°C; the Fischer-Tropsch derived gasoil has a density of 0.76 to 0.80 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 2.0 to 4.5 mm^2/s at 40°C; the Fischer-Tropsch derived base oil has a density of 0.79 to 0.82 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 7.5 to 12.0 mm^2/s at 40°C; and wherein the composition has increased power performance in a diesel injection engine when compared to fuel compositions comprising only a petroleum derived low sulphur diesel comprising <50 ppm of sulphur and a Fischer-Tropsch derived gasoil.

Detailed description of the invention

[0007] According to the present invention it has been shown that high viscosity, low density fuels have favourable power and also neutral to favourable emissions characteristics. The use of Fischer-Tropsch derived components allows breaking of the density-viscosity correlation seen in conventional fuels, allowing higher viscosity fuels for an equal density. Thus using a three-component blend of regular refinery low sulphur diesel (e.g. ULSD), with a Fischer-Tropsch derived gasoil in combination with a Fischer-Tropsch derived base oil 3 (GTL BO3) results in a higher viscosity for the equivalent density of the conventional diesel, to produce higher power performance in diesel engines.

[0008] In this case, a high power fuel can be defined as a fuel which improves the vehicle tractive effort (VTE) and/or the resulting acceleration performance of vehicles fitted with compression ignition engines, compared to conventional diesel. More details on high power fuels and a method for determining VTE can be found in WO2005/054411.

[0009] It has now been found that the use of a specific Fischer-Tropsch derived gasoil in combination with a specific Fischer-Tropsch derived Base Oil 3 allows for blends to be obtained with a higher viscosity at a lower density than is possible by using just a Fischer-Tropsch derived gasoil (as disclosed in WO2005/054411), whilst still complying with the geographically relevant diesel fuel specification (e.g. EN 590), thus allowing a higher power formulation than would otherwise be possible.

[0010] Thus, a further embodiment of the invention relates to the use of a Fischer-Tropsch derived base oil in a fuel composition comprising a petroleum derived low sulphur diesel comprising <50 ppm of sulphur and a Fischer-Tropsch derived gasoil, for the purpose of increasing the power performance of a diesel engine, wherein the amount of the petroleum derived low sulphur diesel is from 60% up to 80% v/v of the total composition; the amount of Fischer-Tropsch derived gasoil is from 10% up to 30% v/v of the total composition; the amount of Fischer-Tropsch derived base oil is from 10% up to 30% v/v of the total composition; the amounts of the Fischer-Tropsch derived gas oil and Fischer-Tropsch derived base oil together being at least 20% v/v of the total composition; and wherein the petroleum derived low sulphur diesel has a density of 0.81 to 0.865 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 1.5 to 4.5 mm^2/s at 40°C; the Fischer-Tropsch derived gasoil has a density of 0.76 to 0.80 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 2.0 to 4.5 mm^2/s at 40°C; and the Fischer-Tropsch derived base oil has a density of 0.79 to 0.82 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 7.5 to 12.0 mm^2/s at 40°C.

[0011] According to the invention, the amount of Fischer-Tropsch derived gasoil is from 10% up to 30% v/v of the total composition and the amount of Fischer-Tropsch derived base oil is from 10% up to 30% v/v of the total composition while the amounts of the Fischer-Tropsch derived gas oil and Fischer-Tropsch derived base oil together at least are 20% v/v of the total composition. Preferably, the amount of Fischer-Tropsch derived base oil is from at least 15%, more preferred at least 20%, and most preferred 30% v/v of the total composition. On the other hand, the amount of Fischer-Tropsch derived gasoil is preferably from 10% up to 20%, and more preferred 10% v/v of the total composition. In a preferred embodiment of this invention the fuel composition comprises 60% v/v of the petroleum derived low sulphur diesel, 10% v/v of the Fischer-Tropsch derived gasoil and 30% v/v of the Fischer-Tropsch derived base oil.

[0012] The paraffinic nature of the Fischer-Tropsch derived components in the present invention (gasoil and base oil) mean that the high power fuel compositions of the present inventions will have high cetane numbers compared to conventional diesel. It is well known that high cetane number fuels can be beneficial for reducing emissions compared to conventional diesel. Therefore, as well as the low density emissions benefits, the high power formulations in the present invention may also have further emissions benefits as a consequence of their high paraffinic content and high cetane number.

[0013] Fuel compositions of the present invention are particularly suitable for use as a diesel fuel, and they are especially useful for arctic applications, as winter grade diesel fuel. Accordingly, a further embodiment of the invention relates to the use of fuel compositions according to the present invention as a fuel in a direct or indirect injection diesel engine, in particular in conditions requiring a fuel with good cold flow properties. For example, a cloud point of -10°C or lower or a cold filter plugging point (CFPP) of -20°C or lower may be possible with fuel compositions according to the present invention. Both Fischer-Tropsch derived base oil and Fischer-Tropsch derived gasoil can have a lower inherent CFPP than the low sulphur diesel component. This means that the proposed formulation will be expected to have improved cold flow performance over the diesel component, enabling the formulation to be used as winter grade fuel, or in the case of forming a formulation with a base diesel with better cold flow, even an arctic grade could be achieved.

[0014] The petroleum derived low sulphur diesel comprising <50 ppm of sulphur according to the invention may be for example an ultra low sulphur diesel (ULSD) or a Zero sulphur diesel (ZSD). Preferably, the low sulphur diesel comprises <10 ppm of sulphur.

[0015] The petroleum derived low sulphur diesel used in the present invention will typically have a density from 0.81 to 0.865, preferably 0.82 to 0.85, more preferably 0.825 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.

[0016] By "Fischer-Tropsch derived" is meant that the gasoil or base oil is, or derives from, a synthesis product of a Fischer-Tropsch condensation process. The Fischer-Tropsch reaction converts carbon monoxide and hydrogen into longer chain, usually paraffinic, hydrocarbons:

$n\,(CO + 2H_2) = (-CH_2-)_n + nH_2O$ + 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.

[0017] 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.

[0018] A Fischer-Tropsch gasoil product or base oil product may be obtained directly from the Fischer-Tropsch reaction, or indirectly for instance by fractionation of a Fischer-Tropsch synthesis product or from a hydrotreated Fischer-Tropsch synthesis product. 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.

[0019] 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 EP0583836.

[0020] 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 Burgt et al (*vide supra*). This process 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 produce liquid transport fuels such as the gasoils useable in diesel fuel compositions. 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. (Gas)oils prepared by the SMDS process are commercially available for instance from the Royal Dutch/Shell Group of Companies.

[0021] Preferably the Fischer-Tropsch derived gasoil or base oil according to the present invention is a product prepared by a Fischer-Tropsch methane condensation reaction using a hydrogen/carbon monoxide ratio of less than 2.5, preferably less than 1.75, more preferably from 0.4 to 1.5. Further, preferably the Fischer-Tropsch derived (gas)oil according to the present invention is a product prepared by the SMDS process, utilising fixed-bed multi-tubular reactors and a promoted cobalt catalyst. Suitably it will have been obtained from a hydrocracked Fischer-Tropsch synthesis product, or a product from a two-stage hydroconversion process such as that described in EP0583836.

[0022] In accordance with the present invention, the Fischer-Tropsch derived gasoil or base oil will consist of at least 95% w/w, more preferably at least 98% w/w, and most preferably up to 100% w/w of paraffinic components, preferably iso- and normal paraffins. Some cyclic paraffins may also be present. According to the present invention the weight ratio of iso-paraffins to normal paraffins is suitably from 0.3 up to 12, in particular from 2 to 6.

[0023] By virtue of the Fischer-Tropsch process, a Fischer-Tropsch derived gasoil or base oil 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.

[0024] The Fischer-Tropsch derived gasoil used in the present invention will typically have a density from 0.76 to 0.80, preferably 0.77 to 0.79, more preferably 0.775 to 0.785 g/cm^3 at 15°C; a cetane number (ASTM D613) greater than 70, suitably from 74 to 85; a kinematic viscosity (ASTM D445) from 2.0 to 5.0, preferably from 2.2 to 4.2, more preferably from 2.5 to 4.0, mm^2/s at 40°C; and a sulphur content (ASTM D2622) of 5 ppmw (parts per million by weight) or less, preferably of 2 ppmw or less.

[0025] The Fischer-Tropsch derived base oil used in the present invention will typically have a density from 0.79 to 0.82, preferably 0.800 to 0.815, and more preferably 0.805 to 0.810 g/cm^3 at 15°C; a kinematic viscosity (ASTM D445) from 7.5 to 12.0, preferably 8.0 to 11.0, more preferably from 9.0 to 10.5, mm^2/s at 40°C; and a sulphur content (ASTM D2622) of 5 ppmw (parts per million by weight) or less, preferably of 2 ppmw or less.

[0026] Generally speaking, in the context of the present invention the fuel composition may be additivated with further additives. Unless otherwise stated, the (active matter) 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 composition; those added to a base fuel at the refinery for example might be selected from anti-static agents, pipeline drag reducers, flow improvers (e.g., ethylene/vinyl acetate copolymers or acrylate/maleic anhydride copolymers), lubricity enhancers, anti-oxidants and wax anti-settling agents.

[0027] The fuel composition may for instance include 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 an engine, in particular in the fuel injection system such as in the injector nozzles. Such materials are sometimes referred to as dispersant additives. Where the fuel composition includes a detergent, preferred concentrations are in the range 20 to 500 ppmw active matter detergent based on the overall fuel composition, more preferably 40 to 500 ppmw, most preferably 40 to 300 ppmw or 100 to 300 ppmw or 150 to 300 ppmw. Detergent-containing diesel fuel additives are known and commercially available. Examples of suitable detergent 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.

[0028] Other components which may be incorporated as fuel additives, for instance in combination with a detergent, include lubricity enhancers; dehazers, *e.g.* alkoxylated 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.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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, emissions benefits often being more marked in heavy-duty engines. As discussed above, the viscosity increasing components in this present invention do not increase the density of the formulation and so there is no detriment to the emissions performance compared to conventional diesel. Moreover, the same component is able to impart both high viscosity and low density, and so this new invention offers the opportunity of producing high power fuels with emissions benefits as opposed to just emissions neutrality. These emissions benefits compared to conventional diesel are expected to be due to both i) the lower density and ii) the higher cetane number provided by the Fischer-Tropsch derived viscosity increasing components.

Legend to the drawings

[0033]

Fig.1. Viscosity-density properties of potential formulations relating to this invention containing Fischer-Tropsch (GTL) gasoil, Fischer-Tropsch (GTL) Base oil 3 and conventional diesel according to the invention.

Fig.2. Viscosity-density properties of components used in the present invention and components used according to WO2005/054411 (Gravex 925, HVI55).

Fig.3. Expected acceleration, VTE, resp. smoke benefit vs. %v/v of Fischer-Tropsch derived viscosity components (in 50/50 ratio) included.

Fig. 4. Modelled cloud point vs. %v/v of Fischer-Tropsch derived viscosity components (in 50/50 ratio) included.

[0034] The invention is illustrated by the following nonlimiting examples.

Examples

Example 1

[0035] A Shell internal fuel blend modelling program 'blendpro 2000' was used to model the density and viscosity of a range of potential blends of the three components. The properties of the components used in this modelling are listed in Table 1.

[0036] The complete possible blend range from 0 - 100% of each component was modelled at 10% increments, as represented in Table 2 and Figure 1.

Table 1. Components used for 'blendpro' modelling

Name	ULSD	GTL Gasoil	GTL BO3
Density (Kg/l)	0.834	0.784	0.807
IBP	166.0	227.7	334.0
T10%	205.0	247.1	353.0
T20%	225.0	259.4	354.5
T30%	244.0	271.2	356.0
T40%	259.0	282.7	357.0
T50%	272.0	293.2	358.5
T60%	284.0	303.4	360.5
T70%	295.0	313.3	362.5
T80%	309.0	323.1	364.5
T90%	325.0	336.0	367.5
T95%	339.0	346.1	370.0
FBP	355.0	351.3	374.0
Cetane Number	53.5	89.8	72.0
Viscosity (cSt) at 40 deg	2.68	3.43	9.58
Sulphur (ppm w)	48.0	3.0	1.0
Total Aromatics	24.3	0.5	0.1
Cloud Point(C)	-8.0	-9.0	-28.0
Flash Point(C)	64.5	104.0	190.0
ULSD = Ultra Low Sulphur Diesel (50mg S/kg)			

Table 2. Modelled Density and Viscosity of the possible blends

ULSD (%v/v)	GTL BO3 (%v/v)	GTL Gasoil (%v/v)	Density @ 15C (kg/l)	Viscosity @ 40C (cSt)
0	100	0	0.8066	9.581
0	90	10	0.80432	8.499838
0	80	20	0.80204	7.573642
0	70	30	0.79976	6.776231
0	60	40	0.79748	6.086422
0	50	50	0.7952	5.486983
0	40	60	0.79292	4.963817
0	30	70	0.79064	4.505333
0	20	80	0.78836	4.101953
0	10	90	0.78608	3.74572
0	0	100	0.7838	3.43
10	90	0	0.80935	8.208112
10	80	10	0.80707	7.322896
10	70	20	0.80479	6.559662

(continued)

ULSD (%v/v)	GTL BO3 (%v/v)	GTL Gasoil (%v/v)	Density @ 15C (kg/l)	Viscosity @ 40C (cSt)
10	60	30	0.80251	5.898509
10	50	40	0.80023	5.323216
10	40	50	0.79795	4.820495
10	30	60	0.79567	4.379402
10	20	70	0.79339	3.990879
10	10	80	0.79111	3.647396
10	0	90	0.78883	3.34266
20	80	0	0.8121	7.083011
20	70	10	0.80982	6.352186
20	60	20	0.80754	5.718245
20	50	30	0.80526	5.165915
20	40	40	0.80298	4.682664
20	30	50	0.8007	4.258155
20	20	60	0.79842	3.88382
20	10	70	0.79614	3.552526
20	0	80	0.79386	3.258303
30	70	0	0.81485	6.153339
30	60	10	0.81257	5.545251
30	50	20	0.81029	5.014769
30	40	30	0.80801	4.550068
30	30	40	0.80573	4.14138
30	20	50	0.80345	3.780597
30	10	60	0.80117	3.460959
30	0	70	0.79889	3.176804
40	60	0	0.8176	5.37917
40	50	10	0.81532	4.869483
40	40	20	0.81304	4.422462
40	30	30	0.81076	4.028873
40	20	40	0.80848	3.681041
40	10	50	0.8062	3.372556
40	0	60	0.80392	3.098043
50	50	0	0.82035	4.729781
50	40	10	0.81807	4.299618
50	30	20	0.81579	3.920445
50	20	30	0.81351	3.584992
50	10	40	0.81123	3.287181
50	0	50	0.80895	3.021907
60	40	0	0.8231	4.181318

(continued)

ULSD (%v/v)	GTL BO3 (%v/v)	GTL Gasoil (%v/v)	Density @ 15C (kg/l)	Viscosity @ 40C (cSt)
60	30	10	0.82082	3.815913
60	20	20	0.81854	3.492298
60	10	30	0.81626	3.204706
60	0	40	0.81398	2.948289
70	30	0	0.82585	3.715106
70	20	10	0.82357	3.402815
70	10	20	0.82129	3.12501
70	0	30	0.81901	2.877084
80	20	0	0.8286	3.316406
80	10	10	0.82632	3.047978
90	10	0	0.83135	2.9735
100	0	0	0.8341	2.677

[0037] Figure 1 shows the three components to be blended in the present invention as black squares (■). The crosses (+) between these individual components show the modelled density and viscosity of each of the potential blends of the three components (that were modelled). For comparison, the (x) points show the range in density and viscosity of conventional diesel fuels. It can be seen from the figure, all of the possible blends of the three components have a higher viscosity, and a lower density than conventional diesel.

[0038] In Fig.2. the viscosity-density properties of components used in the present invention and components used according to WO2005/054411 are shown. The fuel formulation with increased power according to the disclosure of WO2005/054411 was achieved by using a high viscosity high density component within the formulation (see Fig. 2, upper right corner: Gravex 925, HVI55).

The high viscosity component used in the present invention can be classed as "non-traditional" in the sense that whilst high in viscosity it is actually low in density, i.e. the density is below 0.845 (the maximum density point on EU diesel fuels) (see Fig. 2, lower left corner).

[0039] The modelled density and viscosity data of Table 2 were used to predict the power performance benefits of the proposed formulations via a number of equations. These equations were derived by measuring benefits from a variety of test fuels with different densities and viscosities as described in WO2005/054411.

$$\text{benefit (\%)} = D\Delta\rho + E\Delta\nu + F$$

[0040] Where ρ = density (kg/m3), ν = viscosity (mm2/s or cSt) and D, E and F are constants.

[0041] Specifically, for each specific fuel performance indicator:

$$\text{ave accel benefit (\%)} = 0.215\Delta\rho + 0.18056\Delta\nu - 0.10842$$

$$\text{ave VTE benefit (\%)} = 0.19042\Delta\rho + 1.5058\Delta\nu - 0.25791$$

$$\text{ave smoke filter increase (\%)} = 1.2065\Delta\rho + 4.3827\Delta\nu - 2.7928$$

[0042] To use these equations, what is needed is the difference in density and viscosity between conventional diesel and the proposed formulation. Hence any benefits calculated below are against conventional diesel. Given that in this current invention, the minimum volumetric percentage of conventional low sulphur diesel is expected to be no less than 40%, the predicted acceleration % benefit, VTE % benefit and smoke % increase are calculated for the proposed blends from 40-80% ULSD.

Table 3. Expected benefits for proposed blends

ULSD (%v/v)	GTL BO3 (%v/v)	GTL Gasoil (%v/v)	$\Delta\rho$	$\Delta\nu$	acceleration % benefit	VTE % benefit	smoke % benefit
40*	30*	30*	-0.02334	1.351873	2.33	1.77	-3.10
60	30	10	-0.01328	1.13891	1.95	1.46	-2.18
60	20	20	-0.01556	0.81530	1.36	0.97	-0.76
60	10	30	-0.01784	0.52771	0.84	0.53	0.50
70	20	10	-0.01053	0.72582	1.20	0.83	0.38
70	10	20	-0.01281	0.4480	0.70	0.42	0.84
80	10	10	-0.00778	0.37098	0.56	0.30	1.18
*Not claimed in this current invention							

[0043] NOTE: the smoke % benefit in Table 3 is only the benefit expected from the density and viscosity changes compared to conventional diesel. There are expected to be further smoke emissions benefits for these Fischer-Tropsch containing formulations, arising from the increase in the cetane number but those benefits have not been quantified here.

[0044] Figure 3 shows the acceleration, VTE and smoke percentage benefits, respectively, for some formulations according to the present invention, using the equations in WO2005/054411. For ease of comparison, the two Fischer-Tropsch derived viscosity components (GTL BO3 and GTL Gasoil) are in a 50/50 (v/v) ratio, with this mixture being blended into conventional diesel from 20-60%. More data can be found in Table 3.

[0045] As discussed above, the fuel formulation with increased power according to the disclosure of WO2005/054411 was achieved by using a high viscosity, high density component within the formulation. This had an unfortunate side effect of simultaneously increasing density, which tends to make the smoke emissions poorer. In order to restore the emissions performance, according to WO2005/054411 a low density component needs to be added to the formulation.

[0046] The present invention has the key advantage that it negates the need of the low density component (component iii) according to WO2005/054411. This is because both of the Fischer-Tropsch derived components of the present invention (GTL BO3 and GTL Gasoil) have the ability to simultaneously reduce density and increase viscosity, which results in simultaneous lower emissions and yet increased power.

Cloud points.

[0047] To display the potential of blends according to the present invention in Winter/Arctic applications, the cloud point of each of the same blends as shown in Figure 3 was modelled using 'blendpro'. For ease of comparison, the Fischer-Tropsch derived viscosity components (i.e. the Fischer-Tropsch derived gasoil and the Fischer-Tropsch derived base oil) are in a 50/50 (v/v) ratio, with this mixture being blended into conventional diesel from 0-60%.

[0048] The results are depicted in Fig. 4 and Table 4.

Table 4. Expected cloud point benefits for proposed blends

ULSD	GTL BO3	GTL Diesel	Cloud Point (°C)
40*	30*	30*	-12.9
60	20	20	-11.2
80	10	10	-9.5
*Not claimed in this current invention			

Claims

1. A fuel composition prepared by blending a petroleum derived low sulphur diesel comprising <50 ppm of sulphur with a Fischer-Tropsch derived gasoil and a Fischer-Tropsch derived base oil wherein
the amount of the petroleum derived low sulphur diesel is from 60% up to 80% v/v of the total composition;

the amount of Fischer-Tropsch derived gasoil is from 10% up to 30% v/v of the total composition;
the amount of Fischer-Tropsch derived base oil is from 10% up to 30% v/v of the total composition;
the amounts of the Fischer-Tropsch derived gas oil and Fischer-Tropsch derived base oil together being at least 20% v/v of the total composition;
and wherein
the petroleum derived low sulphur diesel has a density of 0.81 to 0.865 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 1.5 to 4.5 mm^2/s at 40°C;
the Fischer-Tropsch derived gasoil has a density of 0.76 to 0.80 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 2.0 to 4.5 mm^2/s at 40°C;
the Fischer-Tropsch derived base oil has a density of 0.79 to 0.82 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 7.5 to 12.0 mm^2/s at 40°C;
and wherein the composition has increased power performance in a diesel engine when compared to fuel compositions comprising only a petroleum derived low sulphur diesel comprising <50 ppm of sulphur and a Fischer-Tropsch derived gasoil.

2. The fuel composition of claim 1, wherein the Fischer-Tropsch derived gasoil consists of at least 95% w/w, more preferably at least 98% w/w, and most preferably up to 100% w/w of paraffinic components.

3. The fuel composition of claims 1 and 2, wherein the Fischer-Tropsch derived base oil consists of at least 95% w/w, more preferably at least 98% w/w, and most preferably up to 100% w/w of paraffinic components.

4. The fuel composition of any one of claims 1 - 3, wherein the amount of the Fischer-Tropsch derived base oil is at least 15%, more preferred at least 20%, and most preferred 30% v/v of the total composition.

5. The fuel composition of any one of claims 1 - 4, wherein the amount of the Fischer-Tropsch derived gasoil is from 10% up to 20%, and more preferred 10% v/v of the total composition.

6. The fuel composition of any one of claims 1 - 5, wherein the amount of the petroleum derived low sulphur diesel is 60% v/v, the amount of the Fischer-Tropsch derived gasoil is 10% v/v and the amount of the Fischer-Tropsch derived base oil is 30% v/v.

7. The fuel composition of any one of claims 1 - 6, wherein Fischer-Tropsch derived gasoil has a density of 0.77 to 0.79, and more preferably 0.780 to 0.785 g/cm^3 at 15°C.

8. The fuel composition of any one of claims 1 - 7, wherein Fischer-Tropsch derived gasoil has a kinematic viscosity from 2.2 to 4.2, more preferably from 2.5 to 4.0 mm^2/s at 40°C.

9. The fuel composition of any one of claims 1 - 8, wherein Fischer-Tropsch derived base oil has a density of 0.800 to 0.815, and more preferably 0.805 to 0.810 g/cm^3 at 15°C.

10. The fuel composition of any one of claims 1 - 8, wherein Fischer-Tropsch derived base oil has a kinematic viscosity from 8.0 to 11.0, more preferably from 9.0 to 10.5 mm^2/s at 40°C.

11. The fuel composition of any one of claims 1 - 10 wherein the fuel composition has a cloud point of -10°C or lower.

12. The fuel composition of any one of claims 1- 11 wherein the fuel composition has a cold filter plugging point (CFPP) of -20°C or lower.

13. Use of the fuel composition of any one of claims 1-12 for arctic applications, in particular as winter grade diesel fuel.

14. Use of a Fischer-Tropsch derived base oil in a fuel composition comprising a petroleum derived low sulphur diesel comprising <50 ppm of sulphur and a Fischer-Tropsch derived gasoil, for the purpose of increasing power performance of a diesel engine,
wherein
the amount of the petroleum derived low sulphur diesel is from 60% up to 80% v/v of the total composition;
the amount of Fischer-Tropsch derived gasoil is from 10% up to 30% v/v of the total composition;
the amount of Fischer-Tropsch derived base oil is from 10% up to 30% v/v of the total composition;
the amounts of the Fischer-Tropsch derived gas oil and Fischer-Tropsch derived base oil together being at least

20% v/v of the total composition;
and wherein
the petroleum derived low sulphur diesel has a density of 0.81 to 0.865 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 1.5 to 4.5 mm^2/s at 40°C;
the Fischer-Tropsch derived gasoil has a density of 0.76 to 0.80 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 2.0 to 5.0 mm^2/s at 40°C;
the Fischer-Tropsch derived base oil has a density of 0.79 to 0.82 g/cm^3 at 15°C and a kinematic viscosity (ASTM D445) from 7.5 to 12.0 mm^2/s at 40°C.

Patentansprüche

1. Kraftstoffzusammensetzung, hergestellt durch Vermischen eines aus Mineralöl gewonnenen schwefelarmen Diesels umfassend <50 ppm Schwefel mit einem nach dem Fischer-Tropsch-Verfahren gewonnenen Gasöl und einem nach dem Fischer-Tropsch-Verfahren abgeleiteten Basisöl, wobei
die Menge des aus Mineralöl gewonnenen schwefelarmen Diesels 60 % bis 80 % (Vol./Vol.) der Gesamtzusammensetzung beträgt;
die Menge des nach dem Fischer-Tropsch-Verfahren gewonnenen Gasöls 10 % bis 30 % (Vol./Vol.) der Gesamtzusammensetzung beträgt;
die Menge des nach dem Fischer-Tropsch-Verfahren gewonnenen Basisöls 10 % bis 30 % (Vol./Vol.) der Gesamtzusammensetzung beträgt;
die Mengen des nach dem Fischer-Tropsch-Verfahren gewonnenen Gasöls und des nach dem Fischer-Tropsch-Verfahren gewonnenen Basisöls zusammen mindestens 20 % (Vol./Vol.) der Gesamtzusammensetzung betragen;
und wobei
der aus Mineralöl gewonnene schwefelarme Diesel eine Dichte von 0,81 bis 0,865 g/cm^3 bei 15 °C und eine kinematische Viskosität (ASTM D445) von 1,5 bis 4,5 mm^2/s bei 40 °C aufweist;
das nach dem Fischer-Tropsch-Verfahren gewonnene Gasöl eine Dichte von 0,76 bis 0,80 g/cm^3 bei 15 °C und eine kinematische Viskosität (ASTM D445) von 2,0 bis 4,5 mm^2/s bei 40 °C aufweist;
das nach dem Fischer-Tropsch-Verfahren gewonnene Basisöl eine Dichte von 0,79 bis 0,82 g/cm^3 bei 15 °C und eine kinematische Viskosität (ASTM D445) von 7,5 bis 12,0 mm^2/s bei 40 °C aufweist;
und wobei die Zusammensetzung im Vergleich zu Kraftstoffzusammensetzungen, die nur einen aus Mineralöl gewonnenen schwefelarmen Diesel umfassend <50 ppm Schwefel und ein nach dem Fischer-Tropsch-Verfahren gewonnenes Gasöl umfassen, eine erhöhte Leistung in einem Dieselmotor aufweist.

2. Kraftstoffzusammensetzung nach Anspruch 1, wobei das nach dem Fischer-Tropsch-Verfahren gewonnene Gasöl zu mindestens 95 % (Gew./Gew.), bevorzugter zu mindestens 98 % (Gew./Gew.) und am meisten bevorzugt zu bis zu 100 % (Gew./Gew.) aus paraffinischen Komponenten besteht.

3. Kraftstoffzusammensetzung nach den Ansprüchen 1 und 2, wobei das nach dem Fischer-Tropsch-Verfahren gewonnene Basisöl zu mindestens 95 % (Gew./Gew.), bevorzugter zu mindestens 98 % (Gew./Gew.) und am meisten bevorzugt zu bis zu 100 % (Gew./Gew.) aus paraffinischen Komponenten besteht.

4. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 3, wobei die Menge des nach dem Fischer-Tropsch-Verfahren gewonnenen Basisöls mindestens 15 %, bevorzugter zu mindestens 20 % und am meisten bevorzugt 30 % (Vol./Vol.) der Gesamtzusammensetzung beträgt.

5. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 4, wobei die Menge des nach dem Fischer-Tropsch-Verfahren gewonnenen Gasöls 10 % bis zu 20 % und bevorzugter 10 % (Vol./Vol.) der Gesamtzusammensetzung beträgt.

6. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 5, wobei die Menge des aus Mineralöl gewonnenen schwefelarmen Diesels 60 % (Vol./Vol.), die Menge des nach dem Fischer-Tropsch-Verfahren gewonnenen Gasöls 10 % (Vol./Vol.) und die Menge des nach dem Fischer-Tropsch-Verfahren gewonnenen Basisöls 30 % (Vol./Vol.) beträgt.

7. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 6, wobei das nach dem Fischer-Tropsch-Verfahren gewonnene Gasöl eine Dichte von 0,77 bis 0,79 und bevorzugter von 0,780 bis 0,785 g/cm^3 bei 15 °C aufweist.

8. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 7, wobei das nach dem Fischer-Tropsch-Verfahren gewonnene Gasöl eine kinematische Viskosität von 2,2 bis 4,2, bevorzugter von 2,5 bis 4,0 mm^2/s, bei 40 °C aufweist.

9. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 8, wobei das nach dem Fischer-Tropsch-Verfahren gewonnene Basisöl eine Dichte von 0,800 bis 0,815 und bevorzugter von 0,805 bis 0,810 g/cm^3 bei 15 °C aufweist.

10. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 8, wobei das nach dem Fischer-Tropsch-Verfahren gewonnene Basisöl eine kinematische Viskosität von 8,0 bis 11,0, bevorzugter von 9,0 bis 10,5 mm^2/s, bei 40 °C aufweist.

11. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 10, wobei die Kraftstoffzusammensetzung einen Trübungspunkt von -10 °C oder niedriger aufweist.

12. Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 11, wobei die Kraftstoffzusammensetzung einen Filterverstopfungspunkt (Cold Filter Plugging Point, CFPP) von -20 °C oder niedriger aufweist.

13. Verwendung der Kraftstoffzusammensetzung nach einem der Ansprüche 1 bis 12 für arktische Anwendungen, insbesondere als wintertauglicher Dieselkraftstoff.

14. Verwendung eines nach dem Fischer-Tropsch-Verfahren gewonnenen Basisöls in einer Kraftstoffzusammensetzung umfassend einen aus Mineralöl gewonnenen schwefelarmen Diesel umfassend <50 ppm Schwefel und ein nach dem Fischer-Tropsch-Verfahren gewonnenes Gasöl für den Zweck des Erhöhens der Leistung eines Dieselmotors,
wobei
die Menge des aus Mineralöl gewonnenen schwefelarmen Diesels 60 % bis 80 % (Vol./Vol.) der Gesamtzusammensetzung beträgt;
die Menge des nach dem Fischer-Tropsch-Verfahren gewonnenen Gasöls 10 % bis 30 % (Vol./Vol.) der Gesamtzusammensetzung beträgt;
die Menge des nach dem Fischer-Tropsch-Verfahren gewonnenen Basisöls 10 % bis 30 % (Vol./Vol.) der Gesamtzusammensetzung beträgt;
die Mengen des nach dem Fischer-Tropsch-Verfahren gewonnenen Gasöls und des nach dem Fischer-Tropsch-Verfahren gewonnenen Basisöls zusammen mindestens 20 % (Vol./Vol.) der Gesamtzusammensetzung betragen;
und wobei
der aus Mineralöl gewonnene schwefelarme Diesel eine Dichte von 0,81 bis 0,865 g/cm^3 bei 15 °C und eine kinematische Viskosität (ASTM D445) von 1,5 bis 4,5 mm^2/s bei 40 °C aufweist;
das nach dem Fischer-Tropsch-Verfahren gewonnene Gasöl eine Dichte von 0,76 bis 0,80 g/cm^3 bei 15 °C und eine kinematische Viskosität (ASTM D445) von 2,0 bis 5,0 mm2/s bei 40 °C aufweist;
das nach dem Fischer-Tropsch-Verfahren gewonnene Basisöl eine Dichte von 0,79 bis 0,82 g/cm^3 bei 15 °C und eine kinematische Viskosität (ASTM D445) von 7,5 bis 12,0 mm^2/s bei 40 °C aufweist.

Revendications

1. Composition de combustible préparée en mélangeant un diesel à faible teneur en soufre dérivé du pétrole comprenant moins de 50 ppm de soufre avec un gazole dérivé de Fischer-Tropsch et une huile de base dérivée de Fischer-Tropsch, dans laquelle
la quantité du diesel à faible teneur en soufre dérivé du pétrole est comprise entre 60 % et 80 % en volume de la composition totale ;
la quantité de gazole dérivé de Fischer-Tropsch est comprise entre 10 % et 30 % en volume de la composition totale ;
la quantité d'huile de base dérivée de Fischer-Tropsch est comprise entre 10 % et 30 % en volume de la composition totale ;
les quantités du gazole dérivé de Fischer-Tropsch et de l'huile de base dérivée de Fischer-Tropsch étant ensemble au moins de 20 % en volume de la composition totale ;
et dans laquelle
le diesel à faible teneur en soufre dérivé du pétrole a une densité comprise entre 0,81 et 0,865 g/cm^3 à 15 °C et une viscosité cinématique (ASTM D445) comprise entre 1,5 et 4,5 mm^2/s à 40 °C ;
le gazole dérivé de Fischer-Tropsch a une densité comprise entre 0,76 et 0,80 g/cm^3 à 15 °C et une viscosité cinématique (ASTM D445) comprise entre 2,0 et 4,5 mm^2/s à 40 °C ;

l'huile de base dérivée de Fischer-Tropsch a une densité comprise entre 0,79 et 0,82 g/cm^3 à 15 °C et une viscosité cinématique (ASTM D445) comprise entre 7,5 et 12,0 mm^2/s à 40 °C ;
et dans laquelle la composition offre une augmentation des performances de puissance dans un moteur diesel par rapport à des compositions de combustible ne comprenant qu'un diesel à faible teneur en soufre dérivé du pétrole, comprenant moins de 50 ppm de soufre et un gazole dérivé de Fischer-Tropsch.

2. Composition de combustible selon la revendication 1, dans laquelle le gazole dérivé de Fischer-Tropsch se compose d'au moins 95 % en poids, de préférence d'au moins 98 % en poids, et idéalement jusqu'à au moins 100 % en poids de composants paraffiniques.

3. Composition de combustible selon les revendications 1 et 2, dans laquelle l'huile de base dérivée de Fischer-Tropsch se compose d'au moins 95 % en poids, de préférence d'au moins 98 % en poids, et idéalement jusqu'à au moins 100 % en poids de composants paraffiniques.

4. Composition de combustible selon l'une quelconque des revendications 1 à 3, dans laquelle la quantité de l'huile de base dérivée de Fischer-Tropsch est au moins de 15 %, de préférence au moins de 20 % et idéalement de 30 % en volume de la composition totale.

5. Composition de combustible selon l'une quelconque des revendications 1 à 4, dans laquelle la quantité du gazole dérivé de Fischer-Tropsch est comprise entre 10 % et 20 %, et de préférence de 10 % en volume de la composition totale.

6. Composition de combustible selon l'une quelconque des revendications 1 à 5, dans laquelle la quantité du diesel à faible teneur en soufre dérivé du pétrole est de 60 % en volume, la quantité du gazole dérivé de Fischer-Tropsch est de 10 % en volume et la quantité de l'huile de base dérivée de Fischer-Tropsch est de 30 % en volume.

7. Composition de combustible selon l'une quelconque des revendications 1 à 6, dans laquelle le gazole dérivé de Fischer-Tropsch a une densité comprise entre 0,77 et 0,79, et de préférence entre 0,780 et 0,785 g/cm^3 à 15 °C.

8. Composition de combustible selon l'une quelconque des revendications 1 à 7, dans laquelle le gazole dérivé de Fischer-Tropsch a une viscosité cinématique comprise entre 2,2 et 4,2, de préférence entre 2,5 et 4,0 mm^2/s à 40 °C.

9. Composition de combustible selon l'une quelconque des revendications 1 à 8, dans laquelle l'huile de base dérivée de Fischer-Tropsch a une densité comprise entre 0,800 et 0,815, et de préférence entre 0,805 et 0,810 g/cm^3 à 15 °C.

10. Composition de combustible selon l'une quelconque des revendications 1 à 8, dans laquelle l'huile de base dérivée de Fischer-Tropsch a une viscosité cinématique comprise entre 8,0 et 11,0, de préférence entre 9,0 et 10,5 mm^2/s à 40 °C.

11. Composition de combustible selon l'une quelconque des revendications 1 à 10, dans laquelle la composition de combustible a un point de trouble de -10 °C ou moins.

12. Composition de combustible selon l'une quelconque des revendications 1 à 11, dans laquelle la composition de combustible a une température limite de filtrabilité (CFPP) de -20 °C ou moins.

13. Utilisation de la composition de combustible selon l'une des revendications 1 à 12 pour des applications glaciales, en particulier en tant que combustible diesel pour l'hiver.

14. Utilisation d'une huile de base dérivée de Fischer-Tropsch dans une composition de combustible comprenant un diesel à faible teneur en soufre dérivé du pétrole comprenant moins de 50 ppm de soufre et un gazole dérivé de Fischer-Tropsch, dans le but d'augmenter les performances de puissance d'un moteur diesel,
dans laquelle
la quantité du diesel à faible teneur en soufre dérivé du pétrole est comprise entre 60 % et 80 % en volume de la composition totale ;
la quantité de gazole dérivé de Fischer-Tropsch est comprise entre 10 % et 30 % en volume de la composition totale ;
la quantité d'huile de base dérivée de Fischer-Tropsch est comprise entre 10 % et 30 % en volume de la composition totale ;
les quantités du gazole dérivé de Fischer-Tropsch et de l'huile de base dérivée de Fischer-Tropsch étant ensemble

au moins de 20 % en volume de la composition totale ;
et dans laquelle
le diesel à faible teneur en soufre dérivé du pétrole a une densité comprise entre 0,81 et 0,865 g/cm^3 à 15 °C et une viscosité cinématique (ASTM D445) comprise entre 1,5 et 4,5 mm^2/s à 40 °C ;
le gazole dérivé de Fischer-Tropsch a une densité comprise entre 0,76 et 0,80 g/cm^3 à 15 °C et une viscosité cinématique (ASTM D445) comprise entre 2,0 et 5,0 mm^2/s à 40 °C ;
l'huile de base dérivée de Fischer-Tropsch a une densité comprise entre 0,79 et 0,82 g/cm^3 à 15 °C et une viscosité cinématique (ASTM D445) comprise entre 7,5 et 12,0 mm^2/s à 40 °C.

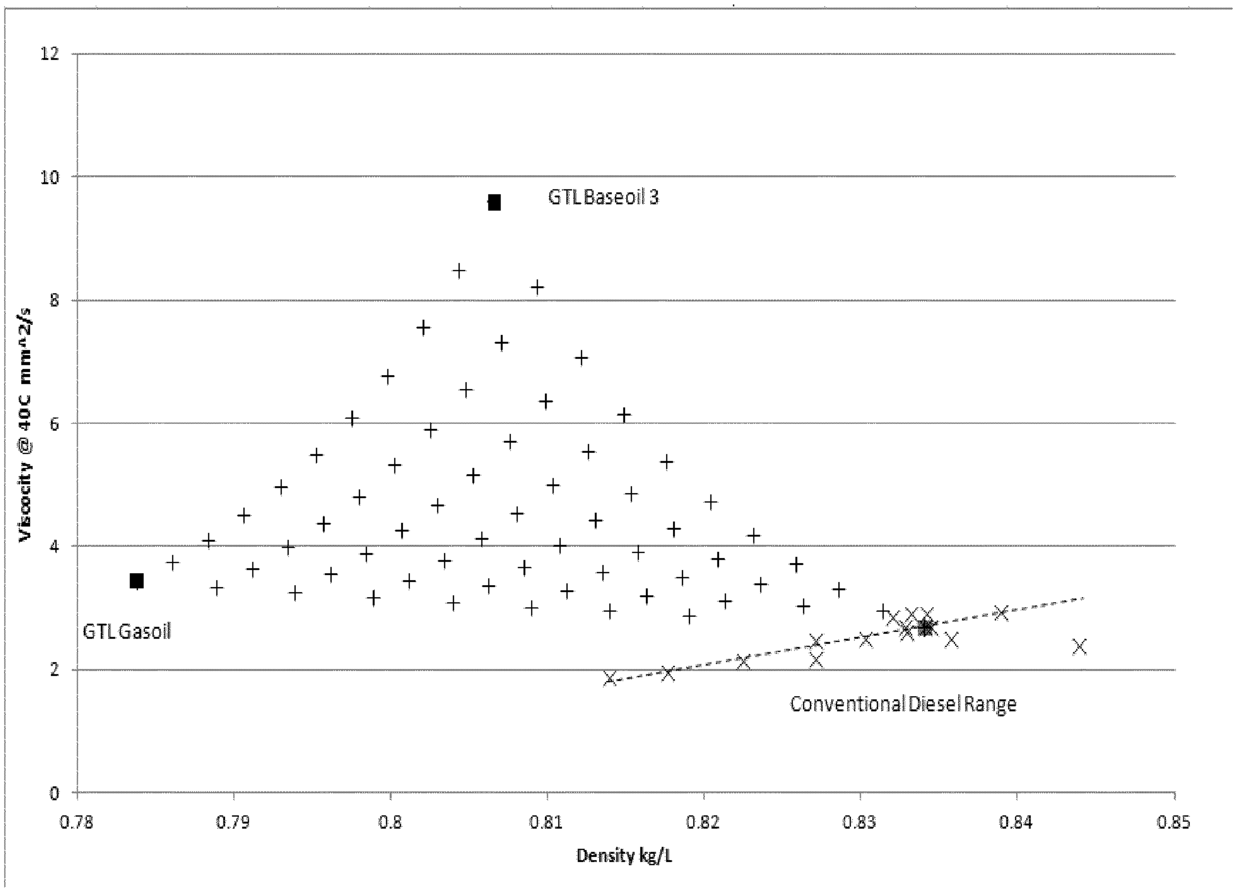
12
10
8
6
4
2
0
Viscocity @ 40C mm^2/s
GTL Baseoil 3
GTL Gasoil
Conventional Diesel Range
0.78
0.79
0.8
0.81
0.82
0.83
0.84
0.85
Density kg/L

Fig. 1.

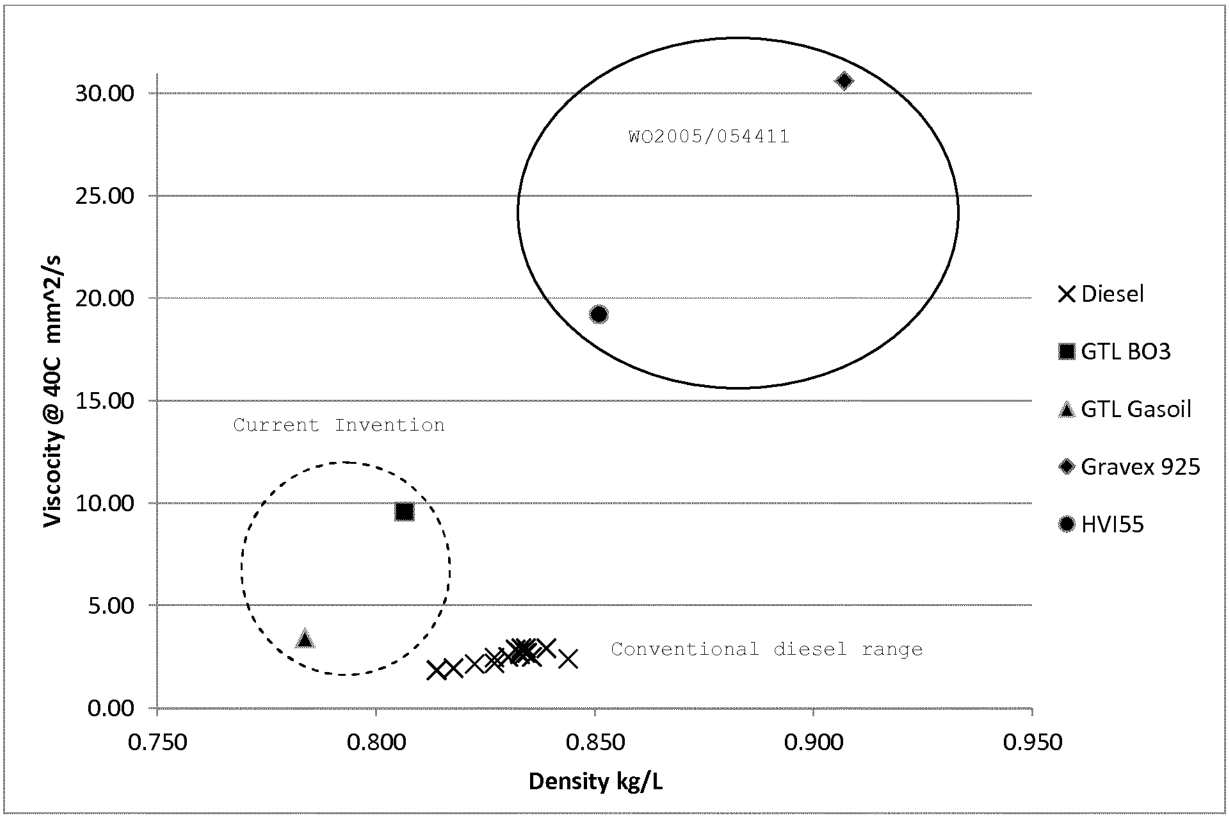
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Viscocity @ 40C mm^2/s
0.750
0.800
0.850
0.900
0.950
Density kg/L
WO2005/054411
Current Invention
Conventional diesel range
Diesel
GTL BO3
GTL Gasoil
Gravex 925
HVI55

Fig. 2.

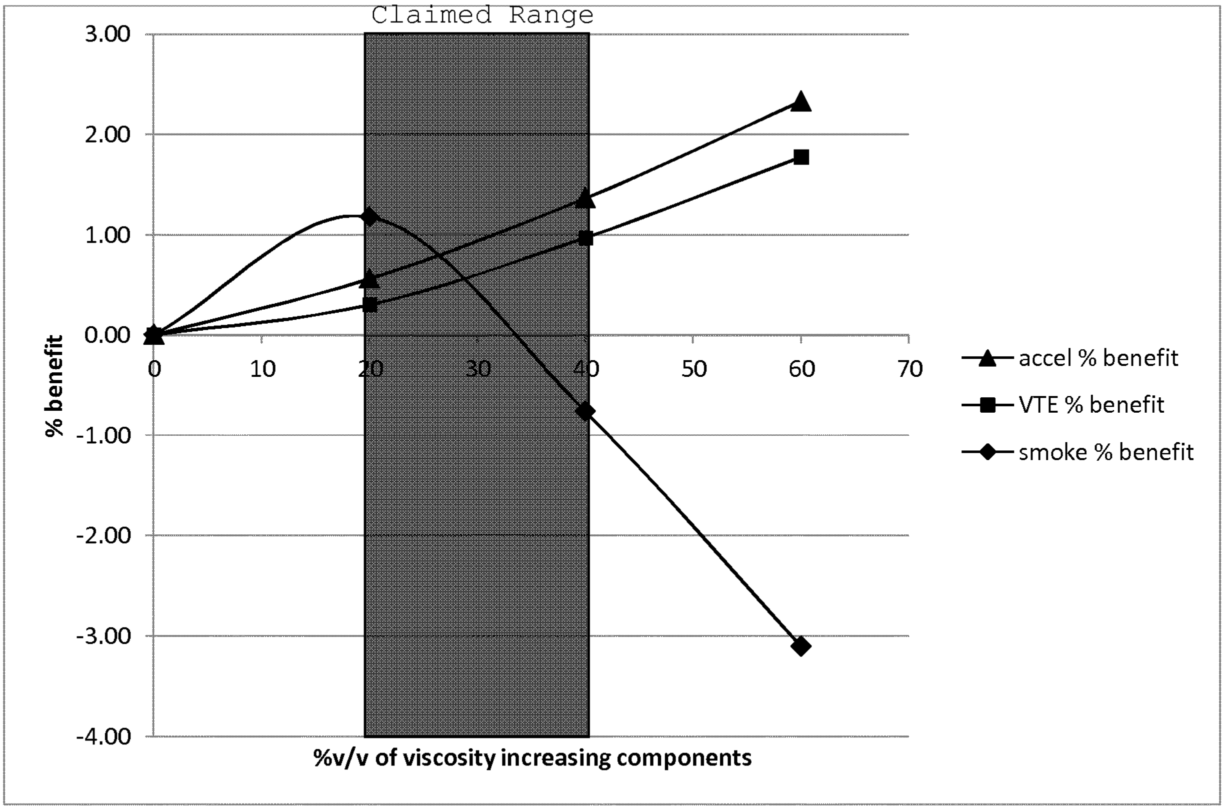
Claimed Range
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
% benefit
0
10
20
30
40
50
60
70
%v/v of viscosity increasing components
accel % benefit
VTE % benefit
smoke % benefit

Fig. 3.

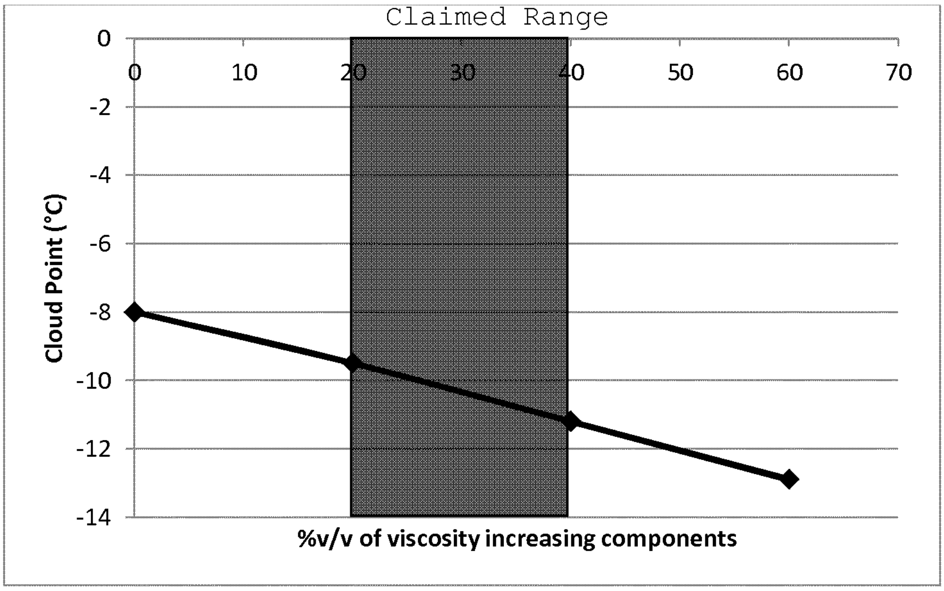
Claimed Range
0
-2
-4
-6
-8
-10
-12
-14
0
10
20
30
40
50
60
70
Cloud Point (°C)
%v/v of viscosity increasing components

Fig. 4.

REFERENCES CITED IN THE DESCRIPTION

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