events occur only sporadically and in an uncontrolled fashion, it is difficult to identify the causes for this phenomenon and to develop solutions to suppress it.

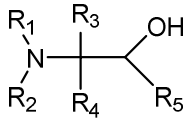
[004] Pre-ignition is a form of combustion that results in ignition of the air-fuel mixture in the combustion chamber prior to the desired ignition of the air-fuel mixture by the igniter. Pre-ignition has typically been a problem during high load engine operation since heat from operation of the engine may heat a part of the combustion chamber to a sufficient temperature to ignite the air-fuel mixture upon contact. This type of pre-ignition is sometimes referred to as hot-spot pre-ignition.

[005] More recently, intermittent abnormal combustion has been observed in boosted internal combustion engines at low speeds and medium-to-high loads. For example, during operation of the engine at 3000 rpm or less, under load, with a brake mean effective pressure (BMEP) of at least 10 bar, low-speed pre-ignition (LSPI) may occur in a random and stochastic fashion. During low speed engine operation, the compression stroke time is longest.

[006] Previous studies have demonstrated that turbocharger use, engine design, engine coatings, piston shape, fuel choice, and/or engine oil additives may contribute to an increase in LSPI events. Accordingly, there is a need for fuel and engine oil additive components and/or combinations that are effective to reduce or eliminate LSPI.

SUMMARY

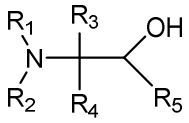
[007] In one aspect, there is provided a fuel composition comprising (1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline ~~or diesel~~ range and (2) a minor amount of a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of an amidine, or a beta-amino alkanol having the structure



, wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic ring, and a C_1-C_{20} alkyl group and R_5 is hydrogen or an

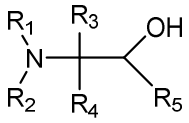
alcohol having the structure –(CH)R_6-OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, wherein the concentration of said one or more of an amidine or a beta-amino alkanol in the fuel composition is from 50 to 5000 ppm by weight.

[008] In another aspect, there is provided a fuel concentrate comprising (1) from 90 to 30 wt % of an organic solvent boiling in a range of from 65°C to 205°C and (2) from 10 to 70 wt % of an additive component selected from one or more of an amidine, or a beta-amino alkanol having the structure



, wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic ring, and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure –(CH)R_6-OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof.

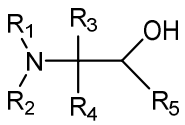
[009] In a further aspect, there is provided a method of reducing low-speed pre-ignition events in an engine comprising providing a fuel composition to the engine, wherein the fuel composition comprises (1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline ~~or diesel~~ range and (2) a minor amount of a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of a triazole, an amidine, a beta-amino alkanol having the structure



, wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure –(CH)R_6-OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, and wherein the engine is a direct-injected, spark-ignited, internal combustion engine that, in operation, generates a brake mean effect

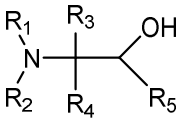
pressure level of greater than 1000 kPa at an engine speed of from 1500 to 2500 rotations per minute.

[009a] In another aspect, there is provided a use of a fuel composition comprising (1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline or diesel range and (2) a minor amount of: a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of an amidine, or a beta-amino alkanol having the



structure , wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic ring, and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure –(CH)R_6OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, to reduce LSPI activity in an engine fuelled with the fuel composition.

[009b] In yet another aspect, there is provided a use of a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of an amidine, or a beta-



amino alkanol having the structure , wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic ring, and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure —(CH)R_6OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, in a fuel composition, to reduce LSPI events, as determined by the method described herein, in a direct-injected, boosted, spark-ignited, internal combustion engine, that, in operation, generates a brake mean effect pressure level of greater than 1000 kPa at an engine speed of from 1500 to 2500 rotations per minute, wherein the direct-injected, boosted, spark-ignited, internal combustion engine is fuelled with the fuel composition, and wherein the fuel composition comprises (1) greater than 50 wt % of

a hydrocarbon fuel boiling in the gasoline range and (2) a minor amount of said low-speed pre-ignition (LSPI)-reducing additive.

DETAILED DESCRIPTION

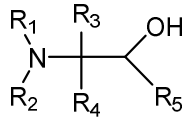
Introduction

[010] In this specification, the following words and expressions, if and when used, have the meanings ascribed below.

CLAIMS

1. A fuel composition comprising (1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline ~~or diesel~~ range and (2) a minor amount of:

a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of an amidine, or a beta-amino alkanol having the structure



,

wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic ring, and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure –(CH)R_6-OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, wherein the concentration of said one or more of an amidine or a beta-amino alkanol in the fuel composition is from 50 to 5000 ppm by weight.

2. The fuel composition of claim 1, wherein:

(i) two or more of R_1, R_2, R_3, and R_4 form a ring structure, or

(ii) at least one of R_1, R_2, R_3 and R_4 is an aromatic ring.

~~3. The fuel composition of claim 1, wherein at least one of R_1, R_2, R_3, and R_4 is an aromatic rings.~~

~~4~~3. The fuel composition of claim 1, wherein the LSPI-reducing additive is an amino alcohol.

~~5~~4. The fuel composition of claim ~~4~~3, wherein the amino alcohol is an aminoheptyl propanediol, an aminooctyl propanediol, or an aminododecyl ethanol,

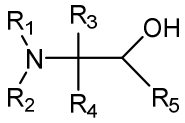
~~6~~5. The fuel composition of claim 1, wherein the LSPI-reducing additive is 3-(heptan-2-ylamino)propane-1,2-diol, 3-(methyl(octyl)amino)propane-1,2-diol, or 2-(methyl(dodecyl)amino)ethan-1-ol.

~~7~~6. The fuel composition of claim 1, wherein the LSPI-reducing additive is DBU 2-methylquinolin-8-olate, or DBU C24-salicylate.

~~8~~7. The fuel composition of claim 1, wherein the salt thereof comprises a secondary additive comprising one or more of: acid additive, phenol additive, 1,3 dicarbonyl additive, hydroxamide additive, antioxidant additive or a salicylate additive.

~~9~~8. A fuel concentrate comprising (1) from ~~90~~ 30 to ~~30~~ 90 wt % of an organic solvent boiling in a range of from 65°C to 205°C and (2) from 10 to 70 wt % of an additive component selected from one or more of

an amidine, or a beta-amino alkanol having the structure



,

wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic ring, and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure –(CH)R_6-OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof.

~~10~~9. The fuel concentrate of claim ~~9~~8, wherein

(i) two or more of R_1, R_2, R_3, and R_4 form a ring structure, or

(ii) at least one of R_2, R_3, and R_4 is an aromatic ring.

~~11. The fuel concentrate of claim 9, wherein at least one of R_1, R_2, R_3, and R_4 is an aromatic rings.~~

~~12~~10. The fuel concentrate of claim ~~9~~8, wherein the LSPI-reducing additive is an amino alcohol.

~~13~~11. The fuel concentrate of claim ~~12~~10, wherein the amino alcohol is an aminoheptyl propanediol, an aminooctyl propanediol, or an aminododecyl ethanol,

~~14~~12. The fuel concentrate of claim ~~9~~8, wherein the LSPI-reducing additive is 3-(heptan-2-ylamino)propane-1,2-diol, 3-(methyl(octyl)amino)propane-1,2-diol, or 2-(methyl(dodecyl)amino)ethan-1-ol.

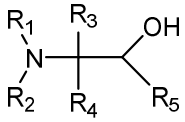
~~15~~13. The fuel concentrate of claim ~~9~~8, wherein the LSPI-reducing additive is DBU 2-methylquinolin-8-olate, or DBU C24-salicylate.

~~16~~14. A method of reducing low-speed pre-ignition events in an engine comprising

providing a fuel composition to the engine, wherein the fuel composition comprises

(1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline ~~or diesel~~ range and (2) a minor amount of a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of:

a triazole, an amidine, a beta-amino alkanol having the structure



,

wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure –(CH)R_6-OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, and

wherein the engine is a direct-injected, spark-ignited, internal combustion engine that, in operation, generates a brake mean effect pressure level of greater than 1000 kPa at an engine speed of from 1500 to 2500 rotations per minute.

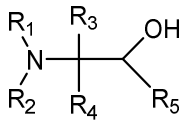
~~17~~15. The method of claim ~~16~~14, wherein the triazole is a benzotriazole.

~~18~~16. The method of claim ~~16~~14, wherein LSPI-reducing additive is an amino alcohol.

~~19~~17. The method of claim ~~16~~14, wherein the amino alcohol is an aminoheptyl propanediol, an aminooctyl propanediol, or an aminododecyl ethanol,

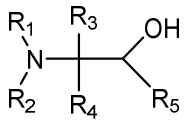
~~20~~18. The method of claim ~~16~~14, wherein the LSPI-reducing additive is 3-(heptan-2-ylamino)propane-1,2-diol, 3-(methyl(octyl)amino)propane-1,2-diol, or 2-(methyl(dodecyl)amino)ethan-1-ol.

19. Use of a fuel composition comprising (1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline or diesel range and (2) a minor amount of a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of an amidine, or a beta-amino alkanol having the structure



wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic ring, and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure –$(CH)R_6OH$ wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, to reduce LSPI activity in an engine fuelled with the fuel composition.

20. Use of a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of an amidine, or a beta-amino alkanol having the structure



wherein R_1, R_2, R_3, and R_4 are each independently selected from hydrogen, aromatic ring, and a C_1-C_{20} alkyl group and R_5 is hydrogen or an alcohol having the structure ––(CH)R_6OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, in a fuel composition, to reduce LSPI events in a direct-injected, boosted, spark-ignited, internal combustion engine, that, in operation, generates a brake mean effect pressure level of greater than 1000 kPa at an engine speed of from 1500 to 2500 rotations per minute, wherein the direct-injected, boosted, spark-ignited, internal combustion engine is fuelled with the fuel composition, and wherein the fuel composition comprises (1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline range and (2) a minor amount of said low-speed pre-ignition (LSPI)-reducing additive.