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.

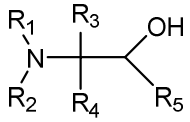
[004] Pre-ignition is a form of combustion that results in ignition of the air-fuel mixture in the combustion chamber prior to the desired ignition of the air-fuel mixture by the igniter. Pre-ignition has typically been a problem during high load engine operation since heat from operation of the engine 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

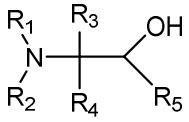
[007] In one aspect, there is provided a fuel composition comprising (1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline range and (2) a minor amount of a low-speed pre-ignition (LSPI)-reducing additive comprising one or more of an amidine, or a beta-amino alkanol having the structure



, 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

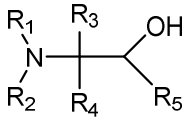
alcohol having the structure –(CH)R_6-OH wherein R_6 is hydrogen, a C_1-C_{10} alkyl group, or a C_1-C_{10} alkenyl group, or a salt thereof, wherein the concentration of said one or more of an amidine or a beta-amino alkanol in the fuel composition is from 50 to 5000 ppm by weight.

[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.

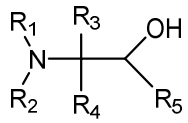
[009] In a further aspect, there is provided a method of reducing low-speed pre-ignition events in an engine comprising providing a fuel composition to the engine, wherein the fuel composition comprises (1) greater than 50 wt % of a hydrocarbon fuel boiling in the gasoline range and (2) a minor amount 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

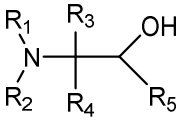
pressure level of greater than 1000 kPa at an engine speed of from 1500 to 2500 rotations per minute.

[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

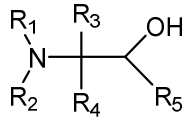
Introduction

[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 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 the LSPI-reducing additive is an amino alcohol.

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

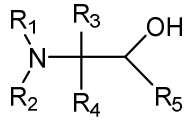
5. The fuel composition of claim 1, wherein the LSPI-reducing additive is 3-(heptan-2-ylamino)propane-1,2-diol, 3-(methyl(octyl)amino)propane-1,2-diol, or 2-(methyl(dodecyl)amino)ethan-1-ol.

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

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.

8. A fuel concentrate comprising (1) from 30 to 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.

9. The fuel concentrate of claim 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.

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

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

12. The fuel concentrate of claim 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.

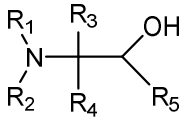
13. The fuel concentrate of claim 8, wherein the LSPI-reducing additive is DBU 2-methylquinolin-8-olate, or DBU C24-salicylate.

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 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.

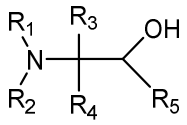
15. The method of claim 14, wherein the triazole is a benzotriazole.

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

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

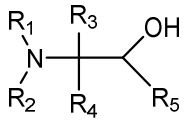
18. The method of claim 14, wherein the LSPI-reducing additive is 3-(heptan-2-ylamino)propane-1,2-diol, 3-(methyl(octyl)amino)propane-1,2-diol, or 2-(methyl(dodecyl)amino)ethan-1-ol.

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.