As the size of the injector nozzle hole is reduced, the relative impact of deposit build up becomes more significant. By simple arithmetic a 5 μm layer of deposit within a 500 μm hole reduces the flow area by 4% whereas the same 5 μm layer of deposit in a 200 μm hole reduces the flow area by 9.8%.

Additives which reduce the formation of deposits in an engine are known. It would be desirable to provide an additive for diesel fuels which would help clean up deposits that have already formed in an engine, in particular deposits which have formed on the injectors.

Summary

In one aspect, there is provided a method of removing deposits from a diesel engine, the method comprising combusting in the engine a diesel fuel composition comprising an engine cleaning additive and a quaternary ammonium salt additive, wherein the engine cleaning additive is the product of a Mannich reaction between:

(a) an aldehyde;

(b) ammonia, hydrazine or an amine; and

(c) an optionally substituted phenol;

wherein the or each substituent of the phenol component (c) has an average molecular weight of less than 400; and wherein the quaternary ammonium salt additive is formed by the reaction of a nitrogen containing species having at least one tertiary amine group and a quarternizing agent; wherein after running the engine for 12 hours, the engine has a power output of at least 97% of the power output obtained when using clean injectors.

In another aspect, there is provided the use of a combination of a quaternary ammonium salt and an engine cleaning to remove deposits from a diesel engine, wherein the engine cleaning additive is the product of a Mannich reaction between:

(a) an aldehyde;

(b) ammonia, hydrazine or an amine; and

(c) an optionally substituted phenol;

wherein the or each substituent of the phenol component (c) has an average molecular weight of less than 400, and wherein the quaternary ammonium salt additive is formed by the reaction of a nitrogen containing species having at least one tertiary amine group and a quarternizing agent; and wherein after running the engine for 12 hours, the engine has a power output of at least 97% of the power output obtained when using clean injectors.

Detailed Description

The present inventors have now found a fuel composition which when combusted in a diesel engine removes deposits therefrom thus effecting the "clean-up" of an already fouled engine.

"Clean-up" of a fouled engine may provide significant advantages. For example superior clean up may lead to an increase in power and/or an increase in fuel economy. In addition removal of deposits from an engine, in particular from injectors may lead to an increase in interval time before injector maintenance or replacement is necessary thus reducing maintenance costs.

According to a first aspect of the present invention there is provided a method of removing deposits from a diesel engine, the method comprising combusting in the engine a diesel fuel composition comprising an engine cleaning additive, wherein the engine cleaning additive is the product of a Mannich reaction between:

(a) an aldehyde;

(b) ammonia, hydrazine or an amine; and

(c) an optionally substituted phenol;

wherein the or each substituent of the phenol component (c) has an average molecular weight of less than 400.

Any aldehyde may be used as aldehyde component (a). Preferably the aldehyde component (a) is an aliphatic aldehyde. Preferably the aldehyde has 1 to 10 carbon atoms, preferably 1 to 6 carbon atoms, more preferably 1 to 3 carbon atoms. Most preferably the aldehyde is formaldehyde.

Component (b) may be selected from ammonia, hydrazine or an amine. It may be a monoamine, for example an optionally substituted alkyl amine. Preferred amines include C1 to C4 primary amines, for example methylamine, and secondary amines.

In preferred embodiments component (b) comprises a polyamine, that is a compound including two or more amine groups.

7. A method according to claim 6 wherein the diesel nitrogen-containing detergent is the reaction product of a hydrocarbyl-substituted carboxylic acid acylating agent and an amine.

8. A method according to any preceding claim wherein the diesel fuel composition further comprises a metal-deactivating compound.

9. A method according to any preceding claim wherein the diesel fuel composition comprises a metal-containing fuel-borne catalyst species to aid with the regeneration of particulate traps.

10. A method according to claim 9, wherein the catalyst species comprises a metal selected from iron, cerium, Group I and Group II metals including calcium, strontium, platinum and manganese.

11. A method according to any preceding claim wherein the diesel fuel composition comprises from 0.1 to 10ppm of a metal containing species.

12. A method according to any preceding claim wherein the diesel engine has a high pressure fuel system, having a pressure in excess of 1350 bar.

13. A method according to any preceding claim wherein after running the engine for 24 hours there is an increase in power output of at least 3%.

14. The use of a combination of a quaternary ammonium salt and an engine cleaning to remove deposits from a diesel engine, wherein the engine cleaning additive is the product of a Mannich reaction between:

(a) an aldehyde;

(b) ammonia, hydrazine or an amine; and

(c) an optionally substituted phenol;

wherein the or each substituent of the phenol component (c) has an average molecular weight of less than 400, and wherein the quaternary ammonium salt additive is formed by the reaction of a nitrogen containing species having at least one tertiary amine group and a quarternizing agent; and wherein after running the engine for 12 hours, the engine has a power output of at least 97% of the power output obtained when using clean injectors.