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.

In one aspect, there is provided a method of removing deposits from a diesel engine having a high pressure fuel system, 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; wherein after running the engine for 32 hours, the engine has a power output of at least 97% of the power output obtained when using clean injectors; and wherein the engine has a pressure in excess of 1350 bar.

In another aspect, there is provided the use of an engine cleaning additive 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; wherein after running the engine for 32 hours, the engine has a power output of at least 97% of the power output obtained when using clean injectors; and wherein the engine has a pressure in excess of 1350 bar.

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.

Claims

1. A method of removing deposits from a diesel engine having a high pressure fuel system, 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; wherein after running the engine for 32 hours, the engine has a power output of at least 97% of the power output obtained when using clean injectors; and wherein the engine has a pressure in excess of 1350 bar.

2. A method according to claim 1 wherein component (b) is a polyethylene polyamine having from 2 to 8 nitrogen atoms.

3. A method according to any one of the preceding claims wherein the engine cleaning additive is present in the diesel fuel composition in an amount of at least 30ppm.

4. A method according to any one of the preceding claim wherein the or each substituent of component (c) has an average molecular weight of less than 300.

5. A method according to any one of the preceding claim wherein the diesel fuel composition further comprises a quaternary ammonium salt additive formed by the reaction of a nitrogen containing species having at least one tertiary amine group and a quarternizing agent.

6. A method according to claim 5 wherein the nitrogen containing species comprises:

   (i) the reaction product of a hydrocarbyl-substituted acylating agent and a compound comprising at least one tertiary amine group and a primary amine, secondary amine or alcohol group;

   (ii) a mannich reaction product comprising a tertiary amine group; and

   (iii) a polyalkylene substituted amine having at least one tertiary amine group.

7. A method according to claim 5 or claim 6 wherein the quaternising agent is selected from dialkyl sulphates, benzyl halides, hydrocarbyl substituted carbonates hydrocarbyl epoxides in combination with an acid, or mixtures thereof.

8. A method according to any one of the preceding claim wherein the fuel composition further comprises one or more nitrogen-containing detergents.

9. A method according to claim 8 wherein the nitrogen-containing detergent is the reaction product of a hydrocarbyl-substituted carboxylic acid acylating agent and an amine.

10. A method according to any one of the preceding claim wherein the fuel composition further comprises a metal-deactivating compound.

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

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

13. The use of an engine cleaning additive 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; wherein after running the engine for 32 hours, the engine has a power output of at least 97% of the power output obtained when using clean injectors; and wherein the engine has a pressure in excess of 1350 bar.

14. The use of an engine cleaning additive according to claim 13 in combination with a nitrogen-containing detergent.