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METHOD FOR PREVENTING CARBONACEOUS DEPOSITS IN DIESEL ENGINES

James F. Scott, Briarcliff Manor, N.Y., assignor to The Perolin Company, Inc., New York, N.Y., a corporation of Delaware

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This invention relates to a method for preventing the fouling of ports and valves in diesel engines. More particularly, the invention relates to the removal and prevention of carbonaceous deposits in and around the ports and valves of diesel engines by adding to the fuel and uniformly distributing therein a source of SiO_2.

There has long been a problem in connection with large industrial and marine diesel engines of loss of efficiency due to fouling of the inlet and exhaust ports and valves with deposits which are predominately carbonaceous in nature. These deposits, which are known in the field as "coke" deposits are made up of carbon, some tars and ash. The ash content of such deposits will vary considerably from only a trace when distillate oil, such as No. 2 oil is being used, to as much as 30–40% when a high ash residual fuel oil is being used in a 2-cycle engine, and even higher amounts when such oil is being used in a 4-cycle engine.

The build-up of "coke" deposit is generally more rapid and extensive at the air inlet ports; and develops more slowly and to a lesser extent at the exhaust ports. In 2-cycle engines the accumulation of coke may advance slowly at first and accelerate as the deposit builds until the air passages in the inlet ports are reduced by 30 to 50% of their original capacity. By the time that this degree of clogging has been reached, and frequently when the clogging is much less advanced, the efficiency of operation will be impaired to an extent such as to require shut down of the engine and mechanical removal of the deposits. Such removal of deposits is difficult and time consuming due to the hard nature of the deposits.

In 4-cycle engines (and 2-cycle engines having exhaust valves) fouling with carbonaceous material develops on the exhaust valves, resulting in improper seating and leakage which necessitates shutting down the engine and replacing fouled valves.

These problems are particularly prevalent and troublesome in the marine diesel engine field, possibly due to substantial difference in type and quality of fuel that is taken on from time to time. It is not uncommon in the marine field for troublesome fouling to develope within 300 to 500 hours of operation, and frequently a point of critical inefficiency will develop at a time requiring shut down of the engines and cleaning and repair at sea.

It has now been discovered, in accordance with the present invention, that the problems of coke accumulation in diesel engines can be overcome by adding to the fuel to be used in such engines, a source of silica to provide the equivalent of about 30 to 300 p.p.m., and preferably about 140 p.p.m. of SiO_2 in the fuel.

Any source of silica capable of uniform distribution throughout the fuel can be used. Thus, for example, colloidal silica, or finely divided inorganic silicate can be mechanically blended with and suspended in the fuel. Alternatively, an oil dispersible or oil soluble organic silicon compound can be blended with the fuel. From the standpoint of ease in obtaining a uniformly treated fuel without special mixing or agitating equipment, the silica is advantageously added as a self-dispersing solution of oil soluble organic silicon compound in an aromatic solvent consisting essentially of methylnaphthalene. This type of self-dispersing solution is disclosed in United States Patent No. 3,003,857.

While the self-dispersing solutions disclosed in United States Patent No. 3,003,857 may be effectively used, at proper dosage, for treating diesel fuels in accordance with the present invention, there is nothing in the disclosure of said patent which would suggest the unique and effective method for preventing coke deposits in diesel engines as herein disclosed.

The reason for or mechanics of the prevention or elimination of coke deposits in diesel engines is not yet fully understood. It appears, however, that these deposits result from incomplete combustion whereby hydrocarbons of the fuel and lubricating oil are to a limited extent converted to carbon in areas where the temperature and/or residence time is insufficient to support complete combustion.

The presence of a source of silica in the fuel apparently provides free SiO_2 in the gases of the combustion chamber which somehow affects the ignition temperature of carbon to permit its more complete combustion. The phenomenon might be compared with the parlor trick of igniting a lump of sugar with a match. A clean lump of sugar will soften and melt without igniting. On the other hand, a lump of sugar that has been dipped in cigarette or cigar ashes will ignite immediately with a match and continue to burn vigorously.

Troublesome coke deposits in diesel engines are experienced with distillate oil (such as No. 2 oil) which is essentially ash free as well as with residual oils which contain varying amounts of ash. Thus, the phenomenon operative in the present method is apparently due to a unique effectiveness of SiO_2 in the proper proportion in the combustion zone, as contrasted with the presence of inorganic components generally.

The following examples will serve to indicate how the method in accordance with the present invention can be carried out, but it is to be understood that these examples are given by way of illustration and not of limitation.

Example I

A low viscosity residual fuel oil, No. 4 oil, is treated with colloidal silica by mixing with a quantity of such oil 10% by weight of colloidal silica having a particle size primarily in the 5 to 10 millimicron range. A uniform and stable dispersion is obtained by extended high speed stirring, or by passing the mixture through a colloid mill.

This dispersion is then combined with additional No. 4 oil at the rate of 2 parts of dispersion to 1000 parts by weight of oil providing about 200 p.p.m. of SiO_2 in the treated oil.

Operation of a 2-cycle marine diesel engine with this treated fuel shows little or no formation of coke deposits at the ports, whereas the same engine with the same, but untreated, fuel shows substantial port clogging with coke within about 400 to 500 hours of operation.

Example II

An additive composition is prepared by combining equal parts by weight of tetraethyl orthosilicate and a methylnaphthalene fraction having a boiling range of 450°–700° F. This additive contains approximately 14% by weight of SiO_2. Therefore, a dosage of 0.02% to 0.1% by weight in diesel fuel will provide about 28 to 140 p.p.m. of SiO_2 in the treated fuel.

On a ship equipped with a 2-cycle 8000 S.H.P. diesel engine, the coke deposits formed in a period of 33 days of operation using residual fuel oils taken on at different ports of call, developed to such an extent that inlet ports of a number of cylinders were about 40 to 60% closed by the deposits. This degree of clogging seriously im-

pairs the engine efficiency, and efficient operation on this ship would require cleaning of the engine ports at much more frequent intervals.

In a test run of this same ship following thorough cleaning of the engine ports, the fuel (again different residual fuel oils taken on at various ports of call) was treated with the above described composition at the rate of one liter per ton, or approximately 1:1000 parts by weight. This dosage provided 140 p.p.m. of SiO_2 in the treated oil.

During the use of the treated oil, no loss of engine efficiency was experienced, and operation was continued for 66 days (1584 hours of actual engine use) without any cleaning of engine ports. At this point, the engine ports were checked and found to be essentially free of coke deposits, with all ports in equally good condition.

Following this inspection, the dosage of the treating composition was reduced to 1:2000 parts by weight (about 70 p.p.m. of SiO_2 in the treated oil). The test run at this dosage is not yet completed, but has continued thus far without loss of engine efficiency or need for cleaning.

Example III

On a ship equipped with highly turbocharged 4-cycle 2800 S.H.P. engines operating with different residual fuel oils taken on at various ports of call, it has been the experience that carbonaceous and ash deposits on and around the valves may sufficiently damage the outlet valves to require replacement within about 180 to 400 hours of operation.

In a test run of this ship, the additive composition described in Example II was used to treat the fuels (again different residual fuel oils taken on at various ports of call) at a dosage of 1 to 500 parts by weight, providing about 280 p.p.m. of SiO_2 in the treated oil. After 2000 hours of operation, all valves were found to be in very good condition with no significant deposits.

In continuing tests at a dosage of 1:1000 parts by weight, providing about 140 p.p.m. of SiO_2 in the treated oil the results to date in preventing valve damage are equally effective; and there is indication that a further reduction in dosage can be made before arriving at the minimum effective dosage for this ship.

Response to additive providing a source of SiO_2 will vary depending on the characteristics of the engine, such as size, operating pressure, etc. For example, an engine rate at 225 lb./sq. in. B.M.E.P. will show a greater tendency for fouling due to carbonaceous deposits than one rated at 100 to 150 lb./sq. in. To the extent that faulty mechanical adjustment of an engine affects combustion of the fuel, it may also affect response to treatment of the fuel with a source of SiO_2. Thus, while an initial dosage providing about 140 p.p.m. of SiO_2 will give generally favorable results with most 2-cycle and 4-cycle diesel engines, the optimum dosage from an economic standpoint will vary from one situation to another. The optimum dosage should approach, but preferably exceed by about 15 to 20% the minimum effective dosage for a given diesel engine installation.

The effectiveness of the new method for preventing carbonaceous deposits as herein disclosed is considered to hinge on introducing the source of silica in an extremely finely divided or dissolved state. Inorganic silicon compounds which would necessarily be dispersed in the oil, rather than dissolved, should have a sub-micron particle size, i.e., below about 1 micron and preferably below about 0.1 micron. It will be recognized that a practical limitation on materials to use in the method is the difficulty in economically reducing inorganic silicon compounds to this degree of fineness. For example, a colloidal silica is obtained in a suitable degree of fineness by a combustion process recovering SiO_2 as a smoke.

Numerous oil dispersible and oil soluble organic silicon compounds are known in the art, and have been disclosed as additives to fuel oil in United States Patents No. 2,843,467 and No. 3,003,857. Many of these compounds, however, are more in the nature of laboratory curiosities than commercial products, and a prime consideration in selecting organic silicon compounds for use in the present method is the relative availability and cost of such compounds. The combustion of fuel containing an organic silicon compound leads to the formation of extremely finely divided SiO_2 in the combustion gases as the active agent for preventing coke deposits in diesel engines in accordance with the present method. Thus, when substituting other sources of silica, whether organic or inorganic, for those shown in the foregoing examples, comparable results are obtained if the amounts or dosage of the source of silica provide the same amounts of SiO_2 in the treated oil.

Field testing of the method herein disclosed has demonstrated not only that diesel engines normally operating on residual fuel oil will operate more efficiently and without fouling due to carbonaceous deposits, but also that engines which normally require the use of distillate fuel oil can be operated efficiently using residual fuel oil treated with a source of silica in accordance with the present method.

Various changes and modifications in the method herein disclosed will occur to those skilled in the art, and to the extent that such changes and modifications are embraced by the appended claims, it is to be understood that they constitute part of the present invention.

I claim:

1. The method of preventing fouling of ports and valves by carbonaceous deposits in heavy diesel engines of the type used in the marine field that comprises operating such engines with a treated fuel consisting of a uniform blend of an oil selected from the group consisting of diesel oil, residual fuel oil, and mixtures thereof, with a silicon containing compound selected from the group consisting of organic and inorganic silicon compounds which provide free SiO_2 at fuel combustion temperature, said silicon compound being present in an amount to provide the equivalent of about 30 to 300 p.p.m. of SiO_2 in said treated fuel.

2. The method of preventing fouling of ports and valves by carbonaceous deposits in heavy diesel engines as defined in claim **1**, wherein the silicon containing compound provides the equivalent of about 70–140 p.p.m. of SiO_2 in said fuel.

3. The method of preventing fouling of ports and valves by carbonaceous deposits in heavy diesel engines as defined in claim **1**, wherein an inorganic silicon compound of sub-micron particle size is employed as the silicon containing compound.

4. The method of preventing fouling of ports and valves by carbonaceous deposits in heavy diesel engines as defined in claim **3**, wherein said inorganic silicon compound has a particle size below about 0.1 micron.

5. The method of preventing fouling of ports and valves by carbonaceous deposits in heavy diesel engines as defined in claim **3**, wherein said inorganic silicon compound is colloidal silica.

6. The method of preventing fouling of ports and valves by carbonaceous deposits in heavy diesel engines as defined in claim **1**, wherein the silicon containing compound is an organic silicon compound.

7. The method of preventing fouling of ports and valves by carbonaceous deposits in heavy diesel engines as defined in claim **1**, wherein the silicon containing compound is an oil soluble organic silicon compound.

8. The method of preventing fouling of ports and valves by carbonaceous deposits in heavy diesel engines as defined in claim **1**, wherein the silicon containing compound is a homogeneous solution of an oil soluble organic silicon compound in an approximately equivalent amount by weight of an aromatic solvent consisting essentially of

methylnaphthalene, and said solution is self-dispersing in the fuel.

References Cited by the Examiner

UNITED STATES PATENTS

2,843,467	7/1958	Rocchini	44—76
3,002,826	10/1961	Norris	44—51
3,003,857	10/1961	Carls	44—80

FOREIGN PATENTS

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DANIEL E. WYMAN, *Primary Examiner.*

W. J. SHINE, *Assistant Examiner.*