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# FUEL COMPOSITION

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## ABSTRACT OF THE DISCLOSURE

Turbine, diesel and motor fuel composition comprising a hydrocarbon or a mixture of hydrocarbons in the middle distillate or kerosene and gasoline boiling ranges containing a bis-(hydroxyethyl) alkane phosphonate in an amount effective to provide a fuel having a high level of anti-wear, anti-icing and rust-inhibiting properties and a method for operating a turbine or diesel engine.

## BACKGROUND OF THE INVENTION

Turbine engines are widely employed in stationary power generating and pumping installations and for powering jet aircraft. These engines are high-powered and consume enormous amounts of the liquid hydrocarbon fuel being used. The fuel requirements of the engine are met with a fuel system incorporating a high capacity fuel pump to deliver the necessary quantity of fuel.

Distillate petroleum hydrocarbon fractions in the kerosene and/or gasoline boiling ranges have essentially no lubricity or lubricating value. In addition, the high solvent action of the fuel and the constant washing by large volumes of fuel make it impossible to maintain any lubricant on the fuel pump surfaces. For these reasons, fuel pumps on turbine engines are subjected to serious wear which leads to failure of the fuel pump and shutdown of the engine.

Turbine fuel compositions having anti-wear properties have been proposed heretofore to solve the problem of fuel pump wear. To date, however, no turbine fuel composition having good anti-wear properties and otherwise suitable as a turbine fuel composition is known to have been commercially adopted.

Liquid hydrocarbon fuels of the types in question are in contact with ferrous metal tanks or pipelines for substantial periods of time. It is essential that the fuel composition be treated or formulated so that it possesses corrosion inhibiting properties. It is also desirable to impart anti-icing properties to the fuel compositions to be employed in internal combustion engines.

It is an object of the present invention to provide a unique fuel composition and a method for operating turbine and diesel engines which substantially reduces or overcomes wear problems encountered in the operation of such engines and also to provide corrosion inhibited fuel compositions including gasoline having carburetor anti-icing properties.

## SUMMARY OF THE INVENTION

In accordance with this invention, an internal combustion engine is run on a fuel composition containing a distillate hydrocarbon fraction and containing a wear-inhibiting amount of bis-(hydroxyethyl) alkane phosphonate. More specifically, the novel fuel composition comprises a liquid hydrocarbon boiling in the range from about 75 to 625° F. containing from about 0.001 to 0.1 weight percent of a bis-(hydroxyethyl) alkane phosphonate represented by the formula:

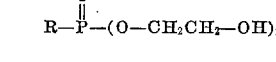




in which R is a hydrocarbyl radical having from about 8 to 20 carbon atoms. A fuel composition for a turbine engine having a fuel system incorporating a high capacity fuel pump and containing a substantial proportion of a kerosene will contain from about 0.01 to 0.1 weight percent of the wear inhibiting additive. A valuable feature of the additive component is that it is non-acidic and non-basic and is less sensitive to the problems that are associated with strongly acidic and basic additives.

The method of operating either a turbine engine or a diesel engine and the fuel composition of the invention are outstandingly effective for substantially reducing wear problems associated with the use of the engines. This performance has been realized by employing the noted additive alone at a concentration level surprisingly found to be effective for producing a fuel having excellent anti-wear properties.

The additive component of the anti-wear fuel composition is a bis-(hydroxyethyl) alkane phosphonate represented by the formula:



in which R is a hydrocarbyl radical having from about 8 to 20 carbon atoms. R is preferably a straight chain or substantially straight chain radical having from 12 to 18 carbon atoms. In general R is a saturated alkyl radical although it can have some unsaturation.

Alkane phosphonates which are useful in this invention include bis-(hydroxyethyl)-tetradecane phosphonate, bis-(hydroxyethyl) - dodecane phosphonate, bis - (hydroxyethyl)-octadecane phosphonate, bis-(hydroxyethyl)-hexadecane phosphonate and mixtures of these and similar prescribed phosphonates.

The base fuel of the invention is a hydrocarbon or mixture of hydrocarbons in the gasoline and/or kerosene boiling ranges. These base fuels boil in a temperature range from about 75 to 625° F. A typical fuel for a turbine engine is JP–4 which contains fractions boiling in the gasoline and kerosene boiling ranges. A middle distillate fraction which can be employed as a jet fuel or a diesel fuel is essentially a kerosene fraction boiling in the range from about 300 to 625° F., and preferably from about 350 to 550° F. All of these base fuels can be characterized as having essentially no lubricity or lubricating properties.

The fuel of the invention consists of a major portion of the base fuel and a wear-inhibiting rust inhibiting or carburetor anti-icing amount of the prescribed bis-(hydroxyethyl) alkane phosphonate generally in the range from about 0.001 weight percent to about 0.1 weight percent. A preferred concentration of the anti-wear additive for a turbine or jet fuel is an amount from about 0.01 to 0.1 weight percent and, more preferably, from about 0.015 to 0.05 weight percent, amounts corresponding to about 40 to 130 PTB pounds of additive per one thousand barrels of fuel. Amounts ranging from about 0.001 to 0.01 are more suitable for gasoline to provide anti-rust and carburetor anti-icing protection. The fuel composition is prepared simply by mixing a suitable amount of the additive to the base fuel.

Minor amounts of other additives may optionally be employed in the fuel composition. It is sometimes desirable to employ a hindered phenol in the fuel composition in an amount effective to impart enhanced oxidation inhibiting properties to the fuel. Effective phenols for this purpose include 2,6-di-t-butyl-4-methyl phenol, 2,6-t-butyl phenol, 4,4'-methylene bis(2,6-di-t-butyl phenol), 2,6-di-t-butyl-4-di-methylaminomethyl phenol, 2,4,6-tri-t-butyl-phenol, and 2,4-di-methyl-6-6-butyl phenol. When a phenol is employed, the amount is generally a concentration ranging from about 1 to 30 pounds per barrel of fuel.

The base fuel employed in the Wear Test below, designated Base Fuel A, was an ($SO_2$) extracted paraffinic base kerosene having the following values:

TABLE I

Inspection test on base fuel A

| | |
|---|---|
| Gravity, ° API | 56.7. |
| Distillation temp., ° F.: | |
| IBP | 75. |
| EP | 500. |
| Sulfur, percent | 0.023. |
| Freezing point, ° F. | Below minus 76°. |
| Heat of combustion B.t.u./lb. | 18,700. |
| Luminometer No. | 82. |
| Aromatic content, percent | 5.0. |

The anti-wear properties of the base fuel and of the fuel composition of the invention determined in the Four-Ball Wear Test. This test follows the procedure of ASTM method D2266–67 with the conditions modified so that the test was run at room temperature under a 5 kilogram load at 600 r.p.m. The scar diameter on the steel balls in millimeters indicates the level of wear obtained with the different fuel compositions.

TABLE II

| Run: | 5 kg., 600 r.p.m., R.T. scar diameter, mm. |
|---|---|
| (1) Base Fuel A | 0.49 |
| (2) Base Fuel A+150 PTB bis-(hydroxyethyl)-tetradecane phosphonate | 0.34 |
| (3) Base Fuel A+150 PTB bis-(hydroxyethyl)-octadecane phosphonate | 0.36 |

The anti-icing properties of an additive-containing fuel of the invention was determined in a carburetor icing demonstrator apparatus consisting of a vacuum pump equipped so that cool, moisture-saturated air from an ice tower is drawn through a simple glass tube gasoline carburetor. The gasoline sample is placed in a sample bottle and is drawn into the glass carburetor through a 20 gauge hypodermic needle. Evaporation of the gasoline in the glass tube further cools the cold moist air with resulting ice formation on the throttle plate. The formation of ice on the throttle plate causes an engine to stall and it has been found that this condition is equivalent to a pressure drop across the throttle plate of about 0.9 inch of mercury and the time required to reach this pressure drop is noted. The vacuum pump is adjusted to give a vacuum of 1.8 inches mercury and the test is run until either a pressure of 2.7 inches mercury has been reached or the run has continued for 300 seconds. Since with most fuels this pressure drop is reached in 1 to 4 minutes, 300 seconds is the maximum time for a run. A fuel composition which provides a minimum of 200 seconds run in this test is an effective carburetor anti-icing fuel composition.

The base fuel, Base Fuel B, employed in the carburetor anti-icing test was a premium grade leaded gasoline having a Research Octane Number of about 100 and boiling in the range from about 75 to 360° F. The test results are set forth in Table III below.

TABLE III

Anti-icing test

| Fuel composition, additives conc.: | Stalling time seconds to 0.9" Hg |
|---|---|
| (1) Base Fuel B | 48 |
| (2) Base Fuel B+2 PTB bis-(hydroxyethyl)-tetradecane phosphonate | 300 |
| (3) Base Fuel B+8 PTB bis-(hydroxyethyl)-tetradecane phosphonate | 300 |

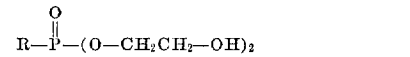
The foregoing data demonstrates that the fuel compositions of the invention containing the prescribed bis-(hydroxyethyl) alkane phosphonates have substantially



improved anti-wear properties and outstanding carburetor anti-icing properties in comparison to the non-additive containing base fuel.

What is claimed is:

1. A liquid fuel composition comprising a mixture of hydrocarbons boiling in the range from about 75° to 625° F. containing from about 0.001 to 0.1 weight percent of bis-(hydroxyethyl) alkane phosphonate having the formula:

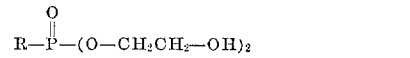


in which R is an alkyl radical having from 8 to 20 carbon atoms.

2. A fuel composition according to claim 1 in which said phosphonate is bis-(hydroxyethyl)-tetradecane phosphonate.

3. A fuel composition according to claim 1 in which R is an alkyl radical having from 12 to 18 carbon atoms.

4. A method of operating an internal combustion engine which comprises supplying to and burning in said engine a liquid fuel composition comprising a mixture of hydrocarbons boiling in the range from about 75° to 625° F. containing from about 0.001 to 0.1 weight percent of a bis-(hydroxy-ethyl) alkane phosphonate having the formula:

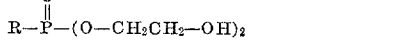


in which R is an alkyl radical having from 8 to 20 carbon atoms.

5. A method according to claim 4 in which said phosphonate is bis-(hydroxyethyl)-tetradecane phosphonate.

6. A method according to claim 5 in which said phosphonate is bis-(hydroxyethyl)-octadecane phosphonate.

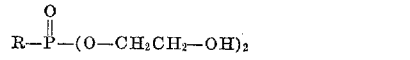
7. An anti-wear turbine fuel composition comprising a mixture of hydrocarbon boiling in the range from about 300 to 625° F. containing from about 0.01 to 0.1 weight percent of a bis-(hydroxyethyl) alkane phosphonate having the formula:



in which R is an alkyl radical having from 8 to 20 carbon atoms.

8. A fuel composition according to claim 7 which said phosphonate is bis-(hydroxyethyl)-tetradecane phosphonate.

9. A fuel composition comprising a mixture of hydrocarbons in the gasoline boiling range containing from about 0.001 to 0.01 weight percent of a bis-(hydroxyethyl) alkane phosphonate having the formula:



in which R is an alkyl radical having from 8 to 20 carbon atoms.

10. A fuel composition according to claim 9 in which said phosphonate is bis-(hydroxyethyl)-tetradecane phosphonate.

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