

[54] **FUEL COMPOSITION**
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[58] Field of Search 44/58, 66

References Cited

UNITED STATES PATENTS

1,825,256 9/1931 Wolfard et al. 44/58

1,826,439 10/1931 Stryker 44/58
2,527,889 10/1950 Moore et al. 44/66

FOREIGN PATENTS OR APPLICATIONS

396,427 8/1933 Great Britain 44/66

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[57] **ABSTRACT**

Turbine and diesel fuel composition comprising a hydrocarbon or a mixture of hydrocarbons in the middle distillate, kerosene or gasoline boiling ranges containing Tall Oil Fatty Acid in an amount effective to provide a fuel having a high level of anti-wear, water separation and thermal stability properties and a method for operating a turbine or diesel engine.

10 Claims, No Drawings

FUEL COMPOSITION

This application is a continuation-in-part of Ser. No. 827,143, filed May 23, 1969, now abandoned.

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 gasoline boiling ranges have essentially no lubricity or lubricating value. This is particularly true of light naphtha which is often economically attractive for fueling power turbines. In addition, the high solvent action of the noted fractions 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.

The demand for a cleaner diesel fuel, i.e., a diesel fuel which produces a reduced level of undesirable pollutants in the exhaust, has necessitated changes in these fuels. Heretofore, the diesel fuels comprised a hydrocarbon fraction which gave satisfactory wear performance in the engine. A cleaner fuel was realized by employing a lighter hydrocarbon fraction but a wear problem developed in diesel engines. For a commercially acceptable clean diesel fuel, it was essential to provide a fuel composition which overcame the wear problem.

The fuels of the invention must also meet other important requirements before they can be employed. In particular, the fuels must be thermally stable, have anti-oxidant properties and have a satisfactory Water Separator Index. The latter property is critical for fuels employed in aircraft because the entrainment of water in the fuel can lead to flame-out or engine failure. In addition, the fuels must be non-corrosive to steel, copper and silver, the principal metals contacted by the fuel in service. This requirement is normally realized with a fuel composition that is essentially free of metallic compounds, sulfur compounds, phosphorous compounds and halogen compounds, impurities which are considered to be corrosive in fuels or to form corrosive combustion products.

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.

DESCRIPTION OF THE PRIOR ART

The use of Tall Oil as a rust inhibitor in liquid mineral oil products, such as gasoline, naphthas and burning oils, is known. U.S. Pat. No. 2,686,715 teaches the use of Tall Oil in mineral oil fractions in a concentration from 0.00003 to about 0.008 weight percent. This reference also teaches that the danger of gum formation is an important limitation in the concentration of Tall Oil which can be used in fuels.

SUMMARY OF THE INVENTION

In accordance with this invention, a turbine engine having a fuel system incorporating a high capacity fuel pump or a diesel engine is run on a light distillate hydrocarbon fraction containing a wear-inhibiting amount of Tall Oil Fatty Acid. More specifically, the novel fuel composition comprises a liquid hydrocarbon boiling in the kerosene and/or gasoline boiling ranges containing from 0.01 to 0.1 weight percent of Tall Oil Fatty Acid.

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 or eliminating wear problems associated with the use of the engines. This performance has been realized by employing the noted additive along at a critical concentration level surprisingly found to be effective for producing a fuel having excellent anti-wear and water separation properties.

The base fuel of the invention is a hydrocarbon or mixture of hydrocarbons in the kerosene and/or gasoline boiling ranges. These base fuels boil in a temperature range from about 90° to 625° F. Typical fuels for turbine engines include JP-3 a mixture of about 70 percent gasoline and 30 percent light distillate having a 90 percent evaporated point of 470° F., JP-4 a mixture of about 65 percent gasoline and 35 percent light distillate and JP-5, an especially fractionated kerosene having a high flash point and a low freezing point. The light distillate fraction employed as a diesel fuel is essentially a kerosene fraction boiling in the range from about 325° to 625° F., preferably from about 350° to 550° F. All of these base fuels are characterized as having essentially no lubricity or lubricating value. Lead compounds, such as tetraethyl lead, are never employed in turbine or diesel fuel compositions.

Tall Oil Fatty Acid is obtained from Tall Oil. Tall Oil is that mixture of saturated and unsaturated fatty and rosin acids which is obtained in paper pulp manufacture when the pulping is done by the sulfate process. In this process, a soap forms and contaminates the pulping liquor. This soap is recovered by acidulating the liquors and skimming the water-insoluble organic material from the liquor.

The Tall Oil can be further separated into Tall Oil Heads and Tall Oil Fatty Acid. In the present invention, there is a further aspect of criticality in the nature of the additive. Only Tall Oil Fatty Acid is effective for the purpose intended. Tall Oil itself is not suitable because it degrades the Water Separator Index of the resultant fuel composition. Tall Oil Heads is not suitable because it has limited solubility in naphtha and light distillate fuels, such as kerosene, below room temperature.

Tall Oil Fatty Acid is a liquid with high solubility in naphtha and kerosene type fuels as well as in n-pentane and isooctane and shows no separation from the fuels at temperatures as low as minus 80° F. It does not affect the Luminometer Number value of the base fuel. Fuel compositions containing Tall Oil Fatty Acid do not form soaps in contact with hard water or sea water and the amount of Tall Oil Fatty Acid extracted from the fuel composition is negligible.

The fuel of the invention consists of a major portion of the base fuel and a wear-inhibiting amount of Tall Oil Fatty Acid in the range from at least 0.01 weight percent to about 0.1 weight percent. A preferred concentration of the Tall Oil Fatty Acid is 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. The fuel composition is prepared simply by admixing a suitable amount of the Tall Oil Fatty Acid 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 fuel compositions in an amount effective to impart enhanced oxidation inhibiting properties to the fuel. Effective phenols 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-methylaminomethylphenol, 2,4,6-tri-t-butylphenol, and 2,4-di-methyl-6-5-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 was an SO₂ extracted paraffinic fuel having the following values:

TABLE I

Inspection Tests on Base Fuel A

Gravity, °API	56.7
Distillation Temp., °F.	
IBP	75
EP	500
Sulfur, %	0.023
Freezing Point, °F.	Below minus 76° F.
Heat of Combustion B.T.U./lb	18,700
Luminometer No.	81
Aromatic Content, %	5

The anti-wear properties of the base fuel and the fuel composition of the invention was determined in the Four-Ball Machine Test. This test employed the machine of ASTM Method D 2266-64T with the following modifications. The test was run under a 10 kilogram load at 1,200 rpm for 30 minutes at room temperature. The wear was obtained on a steel ball cradled in three cadmium plates. Cadmium and steel are the metals in contact in the fuel pump-bore of turbine engines and the test modification simulates the actual wear environment.

TABLE II

Four Ball Machine Tests with Steel in Cadmium

Run	10 Kg, 1200 rpm, Scar Diameter, mm.	30 minutes, R.T. Coefficient of Friction
1. Base Fuel A	2.66	0.25
2. Base Fuel A + 15 PTB Tall Oil Fatty Acid	—	0.28
3. Base Fuel A + 30 PTB Tall Oil Fatty Acid	1.423	0.014
4. Base Fuel A + 60 PTB Tall Oil Fatty Acid		0.052
1.322		
5. Base Fuel A + 100 PTB Tall Oil Fatty Acid	1.4	0.028

Additional fuel compositions were tested for their wear properties in the standard wear test. The inspection values on these fuels are given in the table below:

TABLE III

Base Fuel Inspection Tests

	Base Fuel B	Base Fuel C
Gravity, °API	43.6	36.6
Distillation Temp., °F.		
IBP	330	384
EP	504	610
Freezing Point, °F.	minus 50	
Heat of Combustion, B.T.U./lb	18,500	
Aromatic Content, %	13.5	

The wear properties of the above fuels was determined in the standard Four Ball Wear Test device of ASTM Method D 2266-64T using steel balls. The test results and testing conditions are given in Table IV below:

TABLE IV

Four Ball Wear Test

Run	5 Kg., 600 rpm Room Temp. 1 hour Scar Diameter, mm.
6. Base Fuel B	0.59
7. Base Fuel B + 30 PTB Tall Oil Fatty Acid	0.30
8. Base Fuel B + 60 PTB Tall Oil Fatty Acid	0.27
9. Base Fuel B + 90 PTB	

Tall Oil Fatty Acid	0.26
10. Base Fuel C	0.41
11. Base Fuel C + 90 PTB Tall Oil Fatty Acid	0.32

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The Water Separometer Index (W.S.I.) value of the fuel of the invention was determined according to Federal Test Method 791a-3256 entitled "Determination of Water Separation Properties of Aviation Turbine Fuels." According to this test, 2,000 cc. of fuel plus 2 cc. of water are circulated in a closed system by means of a small gear pump having an output rating of 400 cc. per minute. The microammeter in the apparatus is set before water addition so that the Water Separometer Index value of the base fuel without water is 100. Fuel and water are circulated for five minutes to insure complete mixing of the water-fuel mixture. A portion of this fuel mixture is then circulated through a glass system at a rate of 150 cc./min. This effluent passes through a glass fiber filter coalescer and then through a glass tube equipped with a light and photo-electric cell for determining the light transmission upon which the Water Separometer Index is based. The Water Separometer Index value of the circulated fuel-water mixture is taken in the photoelectric measuring device after the mixture has been passed through the glass filter. The higher the Water Separometer Index the better the fuel is with respect to its water separation properties. A fuel must have a minimum value of 85 to pass the military specification MIL-J-5624F for these fuels. The base fuel from Table I was employed with additive concentrations shown as PTB, pounds of additive per 1,000 barrels of fuel.

TABLE V

Water Separometer Index Test

Base Fuel A + Additive, PTB	Water Separo- meter Index (a)
1. Base Fuel A	98
2. Base Fuel A + 90 PTB Tall Oil Fatty Acid	98
3. Base Fuel A + 90 PTB Tall Oil	74(a)

(a) Average of two runs.

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The fuel composition of the invention possesses outstanding anti-wear and water separation properties as well as good thermal stability and other properties which are essential to the operation of turbine or diesel engines. Overcoming the problem of fuel pump wear in the fuel system of turbine engines without employing metal-containing additive components, sulfur compounds, or halogen compounds which promote corrosion in turbine engines is a very significant improvement. Also, the provision of an anti-wear light distillate diesel fuel composition to reduce atmospheric pollution is a valuable development.

Obviously, many modifications and variations of the invention, as hereinabove set forth, may be made without departing from the spirit and scope thereof, and therefore, only such limitations should be made as are indicated in the appended claims.

I claim:

1. A fuel composition comprising a mixture of hydrocarbons boiling in the range from about 90° to 625°F. containing from 0.01 to 0.1 weight percent of Tall Oil Fatty Acid.
2. A fuel composition according to claim 1 boiling in the range from about 325° to 625°F.
3. A fuel composition according to claim 1 containing from about 0.015 to 0.05 weight percent of said Tall Oil Fatty Acid.
4. An anti-wear turbine fuel composition according to claim 1 comprising a mixture of hydrocarbons boiling in the gasoline and/or kerosene boiling ranges.
5. An anti-wear diesel fuel composition according to claim 1 comprising a mixture of hydrocarbons boiling in the kerosene boiling range.

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6. A method of operating an internal combustion engine which comprises supplying to and burning in said engine a fuel composition comprising a mixture of hydrocarbons boiling in the range from about 90° to 625°F. containing from 0.01 to 0.1 weight percent of Tall Oil Fatty Acid.

7. A method according to claim 6 in which said fuel composition boils in the range of from about 325° to 625°F.

8. A method according to claim 6 in which said fuel composition contains from about 0.015 to 0.05 weight percent of

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said Tall Oil Fatty Acid.

9. A method of operating a turbine engine according to claim 6 which comprises employing an effective anti-wear amount of said Tall Oil Fatty acid in said fuel composition.

10. A method of operating a diesel engine according to claim 6 which comprises employing an effective anti-wear amount of Tall Oil Fatty Acid in kerosene.

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