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METHOD OF LUBRICATING A GAS TURBINE ENGINE

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This invention relates to a method of lubricating gas turbine engines. More particularly, it relates to a method of lubricating a gas turbine engine which comprises maintaining at the points of wear thereof a film of an ester of dipentaerythritol and an alkanoic acid selected from the group consisting of alkanoic acids of 5 to 10 carbon atoms and mixtures of alkanoic acids having from 2 to 12 carbon atoms in proportions to provide an average chain length of from 5 to 10 carbon atoms.

With the development of gas turbine aircraft engines which must operate at peak efficiency at extremely high altitudes there has developed needs for lubricants which are efficacious for long periods of time at the high temperatures at which such engines operate. Up to the present time the gas turbines have operated at maximum bulk oil temperatures of about 300° F. and certain synthetic lubricants, particularly dibasic acid esters such as dioctyl sebacate, have been used successfully for several years. However, the dibasic acid esters which lubricate satisfactorily at a bulk oil temperature of 300° F. have not been found satisfactory under the higher operating temperatures of the newer gas turbine engines.

As a result, many other materials of synthetic origin have been examined as possible lubricants in the new gas turbine engines. Although there are many materials which have looked promising in laboratory evaluation of physical characteristics such as pour point, flash point, etc., actual performance of such materials in engine testing has been disappointing because of excessive sludge and coke deposits. For instance, esters of pentaerythritol and alkanoic acids have many properties that recommend them as lubricants for gas turbines. However, when this class of esters is employed in a gas turbine operating at an oil-in temperature materially above 300° F., there is a substantial build-up of coke, sludge and varnish on the bearings and in the bearing compartments of the engine.

The present invention is based upon the discovery that certain esters of dipentaerythritol, when used as lubricants for gas turbine engines, are particularly outstanding with respect to their ability to maintain engine cleanliness even at bulk oil temperatures in excess of 300° F.

In accordance with this discovery the invention relates to a method of lubricating a gas turbine engine which comprises maintaining on the bearings and other points of wear of the engine a film of a dipentaerythritol ester of an alkanoic acid selected from the group consisting of alkanoic acids having from 5 to 10 carbon atoms and mixtures of alkanoic acids having from 2 to 12 carbon atoms in proportions to provide an average chain length of from 5 to 10 carbon atoms.

The preparation of a dipentaerythritol ester of the type hereinabove defined is illustrated by the following procedure in which parts are by weight:

Into a reaction vessel equipped with a thermometer, stirrer, reflux condenser and water trap, there was placed 254 parts of dipentaerythritol, 1050 parts of a mixture of acids having the following composition:

	Parts
Propionic acid	370
Caprylic acid	350
Caproic acid	330

26 parts of activated carbon, and 75 parts of toluene. The mixture was agitated vigorously and heated to 147° C. where it was held for 4 hours at which point 67 parts of propionic acid was added to compensate for that which was being lost. The temperature was then increased to 185° C. over a period of 3.5 hours. It was held there for one hour and then increased slowly to 200° C. over a period of 3 hours and 15 minutes. The reflux condenser was removed and the temperature was slowly increased to 237° C. over a period of 2.5 hours and was held at this point for 45 minutes. The reaction mixture was then cooled. Excess acids were next stripped off using a nitrogen sparge at a minimum pressure of 2.3 mm., a maximum stripping temperature of 215° C. was reached in 2 hours and the mixture was held there for 30 minutes. The mixture was next cooled to 160° C., slurried with 26 parts of lime for 20 minutes and then filtered through diatomaceous earth. The final ester analyzed: acid number nil, saponification number 398.5, hydroxyl content 0.16%, and hazen color 200.

Other properties of the above ester were as follows:

Specific gravity, 25/25° C	1.0137
Refractive index, 20° C	1.4567
Flash point, ° F	572
Flame point, ° F	617
Pour point, ° F	—50
Evaporation loss, 400° F., 6½ hrs., percent	1.6
Viscosity, cs.:	
At 400° F	1.5
At 210° F	8.9
At 100° F	62.9
At 0° F	5000

From the various properties listed above, it is apparent that the ester has satisfactory flash, flame and pour points for use as a lubricant at high temperatures and that its evaporation loss at 400° F. is relatively small. However, when the ester was evaluated as a lubricant in a gas turbine operating at a bulk oil temperature of 350° F. it was found surprisingly that the cleanliness of the engine was maintained to a remarkable degree over a relatively long period of time.

As a demonstration of the invention, the above ester (admixed with 0.5% phenothiazine by weight of ester) was employed as the lubricant for a 65 hour run in a Pratt and Whitney J–57–P29 gas turbine following the procedure of U.S. Air Force Specification MIL–L–9236. Briefly, in this test the tank of the test engine is filled with the test lubricant and the engine is run through a series of 5-hour cycles at 350° F. oil-in temperature. Each five hours the oil consumption is measured and oil added as necessary. The filter is changed each 25 hours, with the filter weight pick up being measured. Upon completion of the run the engine is disassembled, inspected and photographed. It is then compared to a reference engine to determine the relative deposit rating of the test lubricant. The reference engine is one which has been run by the procedure of MIL–L–7808 using an approved lubricant at an oil-in temperature of 300° F. (See Wright Air Development Center Tech Note 57–212.) In the following table of ratings of the various areas of the engine the symbol A denotes that the test engine was considerably cleaner than the reference engine, the symbol B denotes that the test engine was slightly cleaner than the reference engine and the symbol C denotes the same degree of cleanliness as the reference engine.

A. Main bearings:

#1	B
#2	B
#3	B
#4	B
#4½	B
#5	B
#6	B

B. Bearing compartments:

#1	A
#2	B–C
#3	A
#4	B
#5	B
#6—sump	B

C. Accessory compartments:

N_1 (lo speed)	A
N_2 (hi speed)	A

D. Breathers ---------- B

As seen from the preceding data, the test engine was quite clean. There was an almost complete lack of sludge and varnish, the ratings less than A being the result of slight despositions of coke. Additionally, there was no visible corrosion.

The dipentaerythritol esters employed in the invention can be prepared by the complete esterification of dipentaerythritol with an alkanoic acid or mixture of alkanoic acids as hereinbefore described. Specific esters useful in the invention are, for example, dipentaerythritol hexaheptanoate, dipentaerythritol hexavalerate and dipentaerythritol hexacaproate. Mixed esters useful in the invention can be prepared from mixtures of alkanoic acids such as acetic, propionic, butyric, caproic, caprylic, heptanoic and pelargonic, provided the mixture of acids has an average chain length as prescribed.

The esters, of course, may be blended with one or more additives to further enhance their inherent characteristics.

Such additives include, for example, antioxidants, pour point depressants, detergents, viscosity index improvers and the like.

What I claim and desire to protect by Letters Patent is:

1. A method of lubricating a gas turbine engine which comprises maintaining on the bearings and other points of wear of the engine a film of a dipentaerythritol ester of an alkanoic acid selected from the group consisting of alkanoic acids having from 5 to 10 carbon atoms and mixtures of alkanoic acids having from 2 to 12 carbon atoms in proportions to provide an average chain length of from 5 to 10 carbon atoms.

2. A method of lubricating a gas turbine engine which comprises maintaining on the bearings and other points of wear of the engine a film of a dipentaerythritol ester of mixed alkanoic acids having from 2 to 12 carbon atoms in proportions to provide an average chain length of from 5 to 10 carbon atoms in the mixture.

3. A method of lubricating a gas turbine engine which comprises maintaining on the bearings and other points of wear of the engine a film of a dipentaerythritol ester of mixed alkanoic acids selected from the group consisting of propionic acid, caprylic acid and caproic acid in proportions to provide an average chain length of about 6 carbon atoms in the mixture.

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