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FUEL FOR TWO-CYCLE INTERNAL COMBUSTION ENGINES

Lawrence E. Riemenschneider, 175 Park St., Chelsea, Mich.

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The present invention relates to lubricant motor fuels for two-cycle engines and lubricant additives useful in the formulation of such fuels. The present application is a continuation-in-part of my copending application Serial No. 527,163, filed August 8, 1955, and now U.S. Patent No. 2,896,593.

In the operation of gas engines of the two-cycle type, the lubricating oil is mixed directly with the naphtha or other fuel, as distinguished from other types of gas engines in which the lubricating oil is retained in the crankcase. The mixture consisting of naphtha and a minor proportion of lubricating oil is fed to the combustion chamber, where it is burned. However, the design and carburetion adjustment of the two-cycle engine is necessarily directed toward obtaining the greatest efficiency and maximum horsepower from the naphtha proper, since the best performance of the engine is obviously dependent upon proper combustion of the component which forms by far the greatest part of the fuel mixture. Thus, the lubricant must burn as best it can; and in the case of lubricants known heretofore, faulty combustion of the lubricant component of the fuel mixture has led to a great deal of difficulty.

In particular, faulty combustion of the lubricant component of the fuel mixture has heretofore resulted in carbon and sludge deposits which interfere with the exhaust port and cause fouling of the sparkplugs and sticking of the rings. Moreover, excessive carbon deposits have tended to build up on the head of the piston and in the cylinder head and ring grooves. These difficulties have led to marked reduction in power delivery and have required frequent disassembly and cleaning of the two-cycle engine. With a new, clean engine, no more than thirty hours of operation before cleaning could heretofore be expected; and upon subsequent operation, the time between plug cleaning has dropped to a fraction of this number of hours and in some cases has fallen to less than one hour.

Apart from the reduction in power and necessity for frequent cleaning resulting from such deposits, a further difficulty has arisen apart from operation of the engine and as a result of mere storage of the engine containing fuel mixtures known to the prior art. This difficulty has manifested itself in the form of gummy deposits comprising reaction products of the lubricant and certain components of the naphtha, and in the form of deposits forming a coating on metal parts and commonly known in the art as varnish.

The invention described in my above-mentioned copending application provided a quite satisfactory solution for the above difficulties in the form of a lubricant additive comprising a small proportion of liquid polymers of olefins of which the monomers have not more than five carbon atoms, preferably polyisobutylene.

The additives of the earlier copending application undergo transition stages upon coming into contact with heated engine surfaces. Polyisobutylene, for example, undergoes the transition phase between 230 and 500 degrees Fahrenheit, which, upon cooling, leaves a thin but tacky film upon the cooled metal surfaces. This film is a non-flowing residual inhibitor which is very desirable in that it acts as a rust and corrosion preventative. While this film is very beneficial in the prevention of rust and corrosion during the storage of two-cycle motors, it also

has a somewhat if only temporarily detrimental effect in that the cold motor is somewhat more difficult to crank until fresh fuel comes into contact with these sticky surfaces. Then, however, the tackiness disappears almost immediately and is no longer a drag until the motor has again cooled off.

Moreover, a two-cycle engine which is well designed with regard to cooling, essential tolerances for oil films, and coefficients of expansion of bearing members to maintain these tolerances, will not be subject to temperatures at the bearing surfaces in excess of about 500 degrees Fahrenheit, even when the engine is grossly overloaded. And even at this high temperature, the fuels and fuel additives of my earlier application are quite adequate to provide good lubricity. However, upon occasion, perhaps because of oversight in the inspection of tolerances, or because of developed mechanical distortions and defects, oil film clearances diminish to the vanishing point, whereupon the temperatures of the bearing surfaces will rise above 500 degrees Fahrenheit. Frequently, failures of this type are not due to inherent defects of design, but rather are due to misuse, or the failure of the cooling mechanism, or the result of negligence or ignorance on the part of the user or operator. In any event, even the invention of my earlier application may prove indequate at these higher temperatures, and a shrink fit or seizure may result.

It has now been found that the addition to the additive of my earlier invention of 0.5% to 10% by weight of the additive of polypropylene glycol having an average molecular weight of at least about 600 will raise the temperature tolerance of the lubricant portion of the fuel approximately 75 degrees Fahrenheit, and will also minimize the tackiness of the residual inhibitor film on the cooled motor surfaces thereby reducing the effort necessary to crank the cold motor.

Accordingly, it is an object of my invention to provide a lubricant motor fuel for two-cycle engines, which will leave no appreciable carbon and sludge residue upon combustion.

A further object of my invention is the provision of a lubricating fuel for two-cycle engines, which will permit storage of the engine with greatly reduced gum formation.

A still further object of my invention is the provision of a lubricating fuel for two-cycle engines, which will retain adequate lubricity at greatly elevated temperatures.

Still another object of the invention is the provision of a lubricating additive and lubricating fuel for two-cycle engines, which will leave a non-flowing residual inhibitor on heated engine surfaces, thereby to serve as a rust and corrosion preventative.

A still further object of the invention is the provision of a lubricating fuel for two-cycle engines, which will leave the engine parts in such condition that they may be easily started when cold.

Yet another object of the invention is the provision of a lubricating fuel for two-cycle engines, comprising a homogeneous mixture of mutually miscible components.

Finally, the present invention contemplates lubricating additives for mixture with two-cycle engine fuel, adapted to fulfill the objects listed above.

Other objects and advantages of the present invention will become apparent from the following description and examples.

The lubricating oil component of my invention comprises liquid polymers of olefins of which the monomers have not more than five carbon atoms. Among the operative embodiments are liquid polymers of ethylene, propylene, butylene, isobutylene, and amylene; and particularly preferred is isobutylene. Polymerization of these monomers to the extent necessary to produce a lubricating oil may be carried out according to the method of any

of U.S. Patents Numbers 2,278,445, April 7, 1942; 2,301,-052, November 3, 1942; 2,318,719, May 11, 1943; 2,329,-714, September 21, 1943; 2,345,574, April 4, 1944; or 2,422,443, June 17, 1947. Adequate lubricating properties are obtained when these liquid polymers have average molecular weights of at least about 300, preferably 400 to 500. When polymerization is continued indefinitely, a waxy solid of very much higher average molecular weight is obtained, which, however, is soluble in the lighter petroleum fractions, and hence is usable because of its dilution in the lighter fractions. However, because of the difficulty of compounding fuels by the addition of relatively solid olefin polymers, this invention is primarily concerned with the use of liquid olefin polymers. Although the operative embodiments of monomers are selected from the lower ethylene series, it will of course be understood that tiny included amounts of polymers formed from higher monomers will not seriously affect the operativeness of the invention.

Temperatures up to about 500 degrees Fahrenheit are encountered adjacent the crankcase and cylinder walls of two-cycle engines which are properly operated and in good working condition; and the polymers of the lower ethylene series described above will remain stable somewhat beyond that temperature range. However, these polymers according to the invention will depolymerize to a gaseous state at around 625 degrees Fahrenheit. Inasmuch as the temperatures reached during combustion of the fuel mixture are substantially above this latter temperature, it is obvious that the polymer components of the mixture will retain their lubricating function until combustion and will then completely depolymerize, leaving no undesirable residue. Thus, it does not matter whether the polymeric lubricant component of the fuel mixture burns completely in the combustion chamber, since any unburned portion will depolymerize at the combustion temperatures and be substantially completely exhausted as the monomeric gas from which the polymeric component was initially formed.

Fuel mixtures according to my invention are formed by the thorough mechanical mixing of a small proportion of polymeric lubricant additive according to the invention with a liquid fuel such as naphtha. The two components are mutually miscible in all proportions contemplated by the invention. A preferred proportion of polymeric lubricant additive is 9% by volume of the whole. A proportion of lubricant additive substantially smaller than 6% by volume of the whole gives a decreased lubrication effect. There is no true upper limit to the proportion of lubricant additive, since the polymeric additive is itself an efficient fuel which gives high horsepower. Moreover, as the proportion of additive is increased above 6% by volume of the whole, a cooling effect due to the additive is noted, resulting from the endothermic depolymerization of the additive in the combustion chamber. Thus, while rich mixtures of additive aid in lowering the temperature and add to the horsepower output of the fuel, they are obviously somewhat wasteful from an economic standpoint; and hence, it is not anticipated that additive in excess of about 12% by volume of the whole will be found desirable.

As stated above, the improvement of the present application consists in the addition to the additive of the earlier application of about 0.5% to about 10%, and preferably about 1%, by weight of the additive, of polypropylene glycol having an average molecular weight of at least about 600. Polypropylene glycol and naphtha are mutually miscible in all proportions contemplated by the invention. The effect of the polyglycol is twofold. First, it elevates the temperature tolerance of the lubricant portion of the fuel approximately 75 degrees Fahrenheit, so that effective lubricity is maintained at temperatures as high as 575 degrees Fahrenheit or somewhat more. Second, it minimizes the tackiness of the residual inhibitor film, and thus reduces the effort necessary to start the motor when cold.

Below about 0.5% by weight of the additive, the polyglycol is largely ineffective to produce these results. Above about 10% by weight of the additive, the polyglycol destroys the residual inhibitor film. Inasmuch as polypropylene glycol is hygroscopic, the destruction of the film by use of excessive polyglycol soon results in rusting and corrosion of the vital engine parts.

Below an average molecular weight of about 600, the polyglycol is largely ineffective to produce the desired results. A preferred average molecular weight is about 1200; and very little, if any, increase in lubricity has been found by the use of higher average molecular weight of about 2000 and more. When the polymerization of propylene glycol is continued indefinitely, a waxy solid is ultimately formed; however, this solid is soluble in the lighter petroleum fractions; and in view of its dilution in the fuel solutions, it is useful as well as the lower molecular weight polymers of average weight at least about 600. Therefore, no maximum upper limit for the average molecular weight of the polyglycol can be found by testing any propylene glycol polymers which can be produced by known methods.

A suitable method of forming polypropylene glycol is to heat the monomeric (or dimeric, trimeric, etc.) propylene glycol at a temperature of about 300 to 480 degrees Fahrenheit, preferably 345 to 435 degrees Fahrenheit, in the presence of a dehydration catalyst, such as sulphuric acid, phosphoric acid, iodine, hydrogen iodide, etc. with continuous removal of the water of polymerization. Preferably, the glycol is diluted to control the reaction and to form an easily removed azeotrope with the water of polymerization.

If desired, the stability of the polyglycol may be further improved by partial amine end-group conversion during, but preferably after polymerization, by heating the amine and polymer in the presence of a dehydration catalyst, and preferably in the presence of a solvent. However, the processes of polymerizing the glycol form no part of my invention.

Although the use of polymeric lubricant additives in fuel mixtures according to my invention greatly reduces the amount of harmful deposit when used with a naphtha of any type, it was nevertheless found that some of the deposit was due to the use of generally available gasolenes containing lead and produced by the so-called "cracking" processes. These gasolenes produced by cracking contain a relatively high proportion of unstable molecules known to the art as "wild" molecules which form varnishes on metal surfaces and combine with lubricant to form gums. Moreover, certain components of the residues of combustion of cracked gasolene and lubricating oil mixtures are electrically conductive at the temperatures encountered in the combustion chamber of a two-cycle engine. Heretofore, the harmful effect of the residues and sulphur compounds formed and left by the commonly available gasolenes produced by cracking processes had been completely masked by the greater residues left by lubricant additives heretofore used.

Thus, it was found desirable also to provide the further refinement of the composition of fuel mixtures according to my invention, comprising the use of lead-free, low sulfur, straight run naphtha as the major component of the fuel. By "straight run" naphtha is meant the natural cut having an octane number less than 70, which is obtained from crude oil by ordinary distillation before the remaining crude oil is subjected to cracking for the production of cracked gasolene. Thus, straight run naphtha is sharply distinguished from cracked gasolene, which latter has by contrast a relatively high proportion of wild molecules.

For the purpose of enabling those skilled in the art to practice the invention, the following exemplary illustrations are given:

Example I

As a lubricant additive, a polymer of isobutylene is selected, having a pour point of minus 20 degrees Fahrenheit, a flash point of 215 degrees Fahrenheit, a viscosity at 100 degrees Fahrenheit of 230 Saybolt seconds and a viscosity index at 210 degrees Fahrenheit of 50 Saybolt seconds and a viscosity index of 114. This additive is mixed in the amount of 9% by volume of the whole with a straight run naphtha known as "stove and lighting naphtha" having a lead content of 0, an octane number of 65, a sulphur content of 0.02%, an A.P.I. gravity of 64.5 degrees, and a boiling point range initially at 109 Fahrenheit, 10% at 156 degrees Fahrenheit, 20% at 169 degrees Fahrenheit, 30% at 192 Fahrenheit, 40% at 206 degrees Fahrenheit, 50% at 216 degrees Fahrenheit, 60% at 231 degrees Fahrenheit, 70% at 245 degrees Fahrenheit, 80% at 265 degrees Fahrenheit, 90% at 294 degrees Fahrenheit, and an end boiling point at 339 degrees Fahrenheit. The mixture is burned as fuel in a two-cycle engine; and after 48 hours of operation, no appreciable deposit of residue is noticed in the exhaust port, on the piston head, in the cylinder head, or in the ring groove. Without removal of the fuel from the engine, the engine is permitted to stand for a month; and after the expiration of this latter time, no appreciable deposit of varnish or gum is noticed on any of the parts.

When the motor is started again, there is some degree of difficulty in cranking it; but as soon as fresh fuel comes into contact with the surfaces preserved by the residual inhibitor film, the drag disappears and does not reappear until the motor has again cooled off.

At no time during the above test does the measured temperature of any bearing surface exceed about 500 degrees Fahrenheit.

Example II

Example I is repeated, except that the motor operates for 300 hours, during which the measured temperature of certain bearing surfaces rises to about 575 degrees Fahrenheit, and except that the lubricant additive includes 1% by weight of the additive of polypropylene glycol having an average molecular weight of 1200. Thus, the lubricant additive consists of 99% by weight of polyisobutylene and 1% by weight of polypropylene glycol. After operation, as before, no appreciable deposit of residue is noticed on the parts previously mentioned, and as before, after a month without removal of the fuel, no appreciable deposit of varnish or gum is noticed on any of the parts.

When the motor is again started, it is found to be much easier to crank initially than in the case of Example I.

In both Examples I and II, completely adequate lubricity is maintained even at the highest measured bearing temperatures recited above.

Thus, from a consideration of the foregoing disclosure, it will be obvious that I have achieved all of the initially recited objects of my invention.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

I claim:

1. A fuel for a two-cycle engine consisting essentially of a major proportion of naphtha and not substantially less than 6% by volume of an additive; the additive comprising a major proportion of liquid polymers of lower olefins having an average molecular weight of at least about 300, and about 0.5% to about 10% by weight of the additive of polypropylene glycol having an average molecular weight of at least about 600.

2. A lubricating additive for two-cycle engine fuel, comprising a major proportion of liquid polymers of lower olefins having an average molecular weight of at least about 300 and about 0.5% to about 10% by weight of polypropylene glycol having an average molecular weight of at least about 600.

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