

1

2,983,099

METHOD OF OPERATING A JET PROPULSION MOTOR

Thomas F. Doumani, Whittier, and Clarence S. Coe, Rolling Hills, Calif., assignors to Union Oil Company of California, Los Angeles, Calif., a corporation of California

No Drawing. Original application Apr. 25, 1952, Ser. No. 284,442. Divided and this application July 19, 1954, Ser. No. 444,342

8 Claims. (Cl. 60—35.4)

This application relates to jet propulsion motors, and particularly to methods for improving their efficiency by the provision of certain novel propellants or fuels for such motors. This application is a division of copending application Serial No. 284,442, filed April 25, 1952, which is a continuation-in-part of application Serial No. 539,030, filed June 6, 1944, now U.S. Patent No. 2,645,079.

Jet propulsion motors may be defined, for the purposes of this invention, as motors which derive their driving power from the escape through a jet or nozzle of the relatively large volume of products resulting from the combustion of a fuel by means of an oxidizing agent. The gas jet may be exhausted into the open air as in the rocket type of motor, or it may be trained on a movable piece of machinery such as the blades of a fan in the turbine-type of motor.

The primary requisites of the propellants used in such motors are that they should be safe to handle, stable in storage, should ignite readily and positively, and burn rapidly and smoothly, with a maximum volume of products of combustion. It is ordinarily preferable to oxidize the fuel only to the point where a maximum amount of power is produced per unit weight of oxidizer. This may involve either complete or partial oxidation of the fuel.

It is an object of this invention to supply novel fuels, and novel fuel-oxidizer combinations for jet propulsion motors, whereby their simplicity of construction and efficiency of operation are increased.

It is known that certain classes of organic compounds which contain a polar group, for example, aniline, are more readily oxidizable, i.e., have a lower ignition temperature than most of the straight hydrocarbon fuels. This invention concerns the employment of certain classes of polar compounds as jet fuels which are even more advantageous from the standpoint of ease of oxidation and gas volume production than the previously proposed fuels containing polar groups. The fuels disclosed herein may be employed alone or in combination with hydrocarbon fuels such as petroleum distillates, or they may be mixed with other fuels and/or with an oxidizer.

All of the fuels described herein, except those containing active oxygen as hereinafter defined, require the use of extraneous oxidizing materials for their combustion, i.e. they are not monopropellants. The oxidizers which may be employed include nitric acid, oxygen, and nitrous oxide (these three being preferred), or air, ozone, hydroperoxides, metal peroxides, metal manganates, permanganates, chlorates, perchlorates, hypochlorates, persulfates, chromites, chromates, bichromates and the like, as well as sulfur, the halogens such as fluorine, chlorine, bromine and iodine and their compounds with oxygen, nitrogen and sulfur. Nitro compounds such as nitromethane may also be employed as well as liquid hydrogen peroxide. If nitric acid is employed it is preferable to use fuming nitric acid containing less than about 5% by weight of water. White fuming nitric acid containing less than about 2% of water and substantially no

2

nitrogen dioxide is very suitable, and red fuming nitric acid containing up to about 20% by weight of nitrogen dioxide and less than 5% of water is also excellent, although as indicated fuming nitric acid of greater than 95% concentration is preferred. Any nitric acid having a concentration greater than about 80% may be employed. Liquid nitrogen dioxide may also be employed as well as other oxides of nitrogen.

In cases where the fuel and the oxidizer are compatible with each other at normal temperatures, they may be compounded together in the desired proportions and stored in a single tank or compartment for transfer to the combustion chamber. In this case the combustion chamber must be provided with an igniter such as a spark plug or detonating device. In case the mixture of fuel and oxidizer is a solid or semisolid composition, and is therefore not readily transferred from the storage compartment to the combustion chamber, the fuel and the oxidizer may be blended or intimately mixed and positioned in the combustion chamber itself in such a position that there is no danger of its obstructing the jet. Thus, a mixture of asphalt and potassium perchlorate, for example, may be heated sufficiently to allow it to be poured into the combustion chamber so that it will solidify at the opposite end of the combustion chamber from the jet. It is desirable that when such a mixture is burned, it will burn smoothly at the surface of the charge and not burn in a series of explosions. The additives of this invention aid materially in making the combustion of such a fuel smoother, and in permitting ignition at lower temperatures.

Where either the fuel or the oxidizer is a solid and the other component of the propellant is a fluid the solid material may be positioned in the combustion chamber as described above and the fluid material charged into the combustion chamber from a separate tank or compartment. The proportion of the oxidizer, compared to the fuel in the propellant employed is preferably somewhat less than the amount theoretically required for complete combustion. Generally, proportions between about 50% and about 90% of the amount of oxidizer by weight required for complete combustion are satisfactory, although higher or lower proportions may be necessary in some instances.

In those cases where the fuel and oxidizing material are not compatible with each other, i.e. where the materials will spontaneously ignite upon admixture, it is necessary to provide separate compartments for each component, and each must be separately transferred to the combustion chamber. In this case both components are ordinarily liquids, gases or fluid suspensions and the transfer is accomplished by pressuring each chamber with a piston gas such as nitrogen or other inert gas to force the fuel and oxidizer into the combustion chamber. In this case a separate igniting device is ordinarily not required in the combustion chamber, the fuel igniting spontaneously upon admixture with the oxidizer. Oxidizers which seldom require an ignition device include, for example, hydrogen peroxide, oxygen, nitric acid, and ozone.

The materials which are employed herein either as fuels or as additives to other fuels consist broadly of the highly polar organic nitrogen containing compounds selected from the group consisting of amine oxides, nitriles, imines and oximes. These materials may be designated by the following general formulae:

Amine oxides	Nitriles	Imines	Oximes
R_2NO	$R-CN$	$R=NR'$	$RR'=NOH$

wherein R represents an organic radical and R' is either an organic radical or hydrogen.

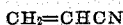
The organic radicals in the above formulae may vary over a wide range. They may include paraffinic, olefinic,

aromatic, naphthenic, or acetylenic residues, and may contain in addition one or more other functional groups. Specific examples of suitable compounds which may be employed include the following:

I. NITRILES



acetonitrile

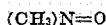


acrylonitrile



benzonitrile

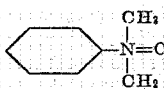
II. AMINE OXIDES



trimethylamine oxide

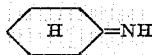


triphenylamine oxide

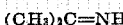


dimethylphenylamine oxide

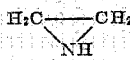
III. IMINES



cyclohexylimine

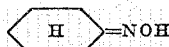


isopropylimine

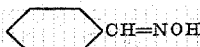


ethyleneimine

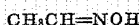
IV. OXIMES



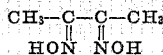
cyclohexanone oxime



benzaldehyde oxime



acetaldehyde oxime



dimethyl glyoxime



trimeric formaldehyde oxime

Many other examples could be cited of compounds similar to the above which are suitable for use as fuels in this invention. In general, homologs, isomers, and substituted derivatives may be employed. The compounds may also contain more than one of the particular functional groups illustrated in the above examples. If substituted compounds are employed, those containing nitro, nitrate, nitrite, nitroso, chloro, bromo, amino, carbonyl, hydroxyl, diazo, azine, hydrazine, and similar substituents, in addition to the particular polar groups illustrated, may be advantageously employed.

The blended jet propulsion fuels of this invention may be prepared by adding the above described materials to another liquid fuel which is either a solvent or a suspending medium for the additive. The preferred fuels employed in such blended mixtures are petroleum gasoline fractions, although higher liquid fractions such as gas oil, kerosene and even lubricating oil fractions, gas fractions such as natural gas or liquefied gas fractions, and even solid or semi-solid fractions may be employed such as petroleum, paraffin wax and asphalt fractions. The additive may be employed in amounts preferably between about 1% and about 10%, although amounts as low as one-hundredth of a percent are effective in some instances and amounts as high as 50% may be employed to advantage in other instances. Combinations of different additives may be employed, and where necessary, as in cases where the additive is insoluble in hydrocarbons, various oxygenated compounds may be employed to alter the solvent capacity of the hydrocarbon fuel. Examples of suitable mutual solvents for the additive and the hydrocarbon include alcohols such as methyl, ethyl or isopropyl, alcohol, acetone, dioxane, and aldehydes.

When the above compounds are employed in conjunction with hydrocarbon fuels, it is generally preferred to use those compounds having a high ratio of polar groups to carbon atoms. Specifically it is preferred to employ those compounds containing not more than about four carbon atoms for each polar functional group. Conversely, when the above fuels are employed without an added hydrocarbon fuel or solvent it is preferred that the hydrocarbon component should be relatively larger. Specifically it is preferred that the compounds should contain more than about four carbon atoms for each functional group.

Any of the above materials may be employed as fuels or fuel additives by one or more of the procedures in the following examples. These examples should, however, be considered as illustrative only and not limiting.

Example I

A liquid fuel is prepared by dissolving 10% by volume of acetonitrile in about 90% of a paraffinic crude gasoline fraction having a boiling range of about 100° F. to 400° F., and containing less than about 10% of aromatic type hydrocarbons. This fuel may be charged into one feed tank of a jet propulsion motor and pressured with nitrogen to about 1500 pounds per square inch. A second feed tank may be charged with fuming nitric acid and similarly pressured with nitrogen. The fuel and the nitric acid oxidizer may then be released from the fuel tanks and fed to a combustion chamber where they are allowed to react spontaneously. This reaction is an oxidation reaction or combustion and the hot gaseous products pass out through a jet in order to provide driving force. For a jet combustion chamber of about 70 cubic inches in size, the rate of fuel injection may be about 2½ pounds for every 3½ pounds of oxidizer. The effect of the acetonitrile in the above fuel is to lower the ignition temperature below that of the gasoline alone, and to make the burning smooth and nonexplosive, thus providing a smooth thrust during the entire period of operation rather than a single explosion or a series of explosive bursts. Similar effects are obtained when any of the above described fuels are added to hydrocarbon fuels.

Example II

A suitable solid propellant for these purposes may be compounded for example from about 20% trimeric formaldehyde oxime, 40% potassium chlorate, and about 40% of a high melting asphalt. To compound the mixture formaldehyde oxime and the potassium chlorate are mixed together and the melted asphalt is stirred into the mixture. The semi-fluid mass may then be poured into the combustion chamber of the jet engine and allowed to solidify at the end opposite from the jet. The material may be combusted when desired by providing a spark ignition near the surface of the mixture, or by a suitable detonating device.

Example III

Another suitable fuel may consist of about 20% ethylene imine dissolved in about 80% ethyl alcohol. This mixture may suitably be combusted with an oxidizer consisting of 100% hydrogen peroxide which is admitted from a separate storage tank to the combustion chamber. The mixture formed in the combustion chamber will ignite spontaneously.

The invention is not limited to the particular conditions described in the above examples, since different pressures, up to several thousand pounds per square inch, different rates of introduction of fuels and oxidizers, generally increasing with the combustion pressure and the size of the motor, and different sizes and styles of equipment may be employed. The fuels of this particular invention are effective in any type of jet propulsion motor to increase the certainty, the smoothness and the efficiency of the combustion.

Modifications of this invention which would occur to one skilled in the art are to be included in the invention as defined in the following claims.

We claim:

1. In a method of operating a jet propulsion motor wherein a fuel is burned in a combustion chamber with a proportion of added oxidizer at least about 50% of the amount required for complete combustion of said fuel, and the products of combustion are allowed to escape through a jet thereby producing a driving force, said oxidizer being selected from the group consisting of oxygen, nitric acid, nitrous oxide and hydrogen peroxide, the improvement which comprises employing therein as

a fuel a composition consisting of a substantial proportion, at least about 1% by volume, of an organic nitrogen compound selected from the group consisting of acetonitrile, acrylonitrile, benzonitrile, trimethylamine oxide, triphenylamine oxide, N,N-dimethyl phenylamine oxide, cyclohexylimine, isopropylimine, cyclohexanone oxime, benzaldoxime, acetaldoxime, dimethyl glyoxime, and trimeric formaldoxime, any remaining component of said fuel consisting essentially of a combustible solvent selected from the group consisting of hydrocarbons, lower aliphatic alcohols, and mixtures thereof.

2. In a method of operating a jet propulsion motor wherein a fuel is burned in a combustion chamber with a proportion of added oxidizer at least about 50% of the amount required for complete combustion of said fuel, and the products of combustion are allowed to escape through a jet thereby producing a driving force, said oxidizer being selected from the group consisting of oxygen, nitric acid, nitrous oxide, and hydrogen peroxide, the improvement which comprises employing therein as a fuel a liquid mixture of a combustible solvent and between about 1% and 50% by volume of an organic nitrogen compound selected from the group consisting of acetonitrile, acrylonitrile, benzonitrile, trimethylamine oxide, triphenylamine oxide, N,N-dimethyl phenylamine oxide, cyclohexylimine, isopropylimine, cyclohexanone oxime, benzaldoxime, acetaldoxime, dimethyl glyoxime,

and trimeric formaldoxime, said combustible solvent being selected from the group consisting of hydrocarbons, lower aliphatic alcohols, and mixtures thereof.

3. A process as defined in claim 2 wherein said combustible solvent is essentially a liquid mineral oil fraction.

4. A process as defined in claim 1 wherein said nitrogen compound is benzonitrile.

5. A process as defined in claim 1 wherein said nitrogen compound is acetonitrile.

6. A process as claimed in claim 1 wherein said nitrogen compound is trimethylamine oxide.

7. A process as defined in claim 1 wherein said nitrogen compound is acetaldoxime.

8. A process as defined in claim 1 wherein said nitrogen compound is trimeric formaldoxime.

References Cited in the file of this patent

UNITED STATES PATENTS

2,573,471	Malina et al. -----	Oct. 30, 1951
2,682,336	Moberly -----	June 29, 1954
2,824,791	Osborg -----	Feb. 25, 1958

OTHER REFERENCES

25	Da Rosa: Journal of the American Rocket Society, No. 61, March 1945, pages 4, 5, 6 and 15, copy in Scientific Lib.
----	--