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COMPOSITE SOLID PROPELLANT CONTAINING PRESHAPED (SALT - METAL - BURNING RATE CONTROLLER) PARTICLES

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ABSTRACT OF THE DISCLOSURE

A composite solid propellant for rocket fuel which comprises a blended solid oxidizer shaped to particles of given form having a minimum length of one milimeter and containing a burning-rate controller distributed throughout or thereover in the form of a thin film or fine particles.

This invention relates to composite solid propellants for rocket fuel. More particularly it relates to novel composite solid propellants comprising a blended solid oxidizer shaped into particles of a given form having a minimum length of one millimeter and a burning-rate controller distributed throughout or thereover in the form of a thin film or fine particles.

Composite solid propellants are usually formed essentially of a solid oxidizer, a metallic fuel, a so-called fuel binder which not only binds the two components together but which also burns itself, with the addition of a burning-rate controller if necessary. They are designed to produce thrust with gases generated by the thermal decomposition of the oxidizer and by the combustion of the fuel binder and metallic fuel with the aid of oxygen from the oxidizer and binder. Above all, the combination of oxygen from the oxidizer and the binder has important significance. For this reason, it has heretofore, been believed necessary that the oxidizer and fuel component be in close contact throughout and hence that the oxidizer and metallic fuel be of the finest possible particle size so far as the circumstances permit. In fact these components in the conventional propellants range from microns to some hundreds of microns in particle size.

However, in solid components of such particle size, if the oxidizer in such an amount that the combined volume of oxygen generated from the oxidizer and the oxygen included in the fuel binder is sufficient for combustion of the propellant as a whole are added, the propellant becomes too viscous to be poured into molds. Actually, therefore, only an insufficient amount of the oxidizer is to be blended with the other ingredients, thus providing propellants of less thrust. Further, if other solids such as burning-rate controllers, which make no direct contributions to the combustion are added, the amount of the oxidizer must be decreased.

The present invention contemplates the elimination of the foregoing disadvantages by providing propellants which are made by mixing three components i.e., oxidizer, metallic fuel and burning-rate controller together, and shaping the mixture to grains of a given form and having a minimum length of one millimeter, which is far larger than the size usually employed for conventional oxidizers, and then combining the grains with a fuel binder. This is contrary to the conventional practice of uniformly mixing all four components of oxidizer, fuel binder, metallic fuel ,and burning-rate controller.

The present invention will now be more fully explained. First, a solid oxidizer, a metallic fuel ,and a burning-rate controller, all in powdery form, are mixed and pressed to the desired shape. These components are preferably

of small particle size. In pressing the mixed powdery materials to shape, it is generally desirable to apply a pressure of more than 3 tons per square centimeter. In the pressing operation, the mixture may be premixed with a small amount of the fuel binder in order to ensure the binding of the composition. Either the mixture or the additive may be in the form of a solution which is mixed intimately with the other and subsequently dried, or both may be mixed in liquid form and precipitated entectoid from the liquid, or the two may be united as by vacuum evaporation. Thus, there is no special limitation in the mixing procedure.

Suitable compounds which may be used as solid oxidizers in accordance with the present invention are those conventionally used in composite solid propellants, including the perchlorates and nitrates of ammonium, alkali metals and alkali earth metals. Typical thereof are ammonium perchlorate, ammonium nitrate, and potassium perchlorate. These solid oxidizing materials may also ue used in the form of a combinations of two or more thereof.

Suitable metallic fuels are those which are combustion stability improvers and specific thrust promoters such as lithium, aluminum, magnesium, boron, and beryllium. They may be used in powdery form singly, in mixtures or as alloys. The shape of the grain is governed by the required burning characteristics such as combustion efficiency and burning rate of the propellant.

The term burning-rate controller as herein used means all substances whose oxidation or oxidizing action is not substantially contributory to the thrust of the propellant but which serves to promote, inhibit or otherwise influence the burning reaction of the composite solid propellant. Such substances include carbon black copper chromite, cuprous oxide, cupric oxide, potassium bichromate, ammonium bichromate, iron oxide, manganese dioxide, potassium permanganate, vanadium oxide, silica, alumina, and other oxidizing catalysts and inert components.

Fuel binders which may be used in the invention are polyurethane, polybutadiene, polysulfide, polyvinyl chloride, nitrocellulose, polynitrourethane and other fuel binders and their plasticizers, stabilizers, age resistors, and other additives usually employed for composite solid propellants may be added.

The shape of the grain of the composite solid oxidizers thus obtained are not limited; they may take the form of granules, tablets, pellets, wires, rods, bars, cords cylinders, sheets, cubes, etc. The shape will be suitably chosen to meet the requirements of the particular application because the shape changes the burning conditions depending on the size and arrangement of the grains. When a blended solid oxidizer is mixed with a fuel binder and the mixture is cast into a propellant grain, the surface area per unit weight of the solid component is far less than that of conventional grains comprising oxidizers in fine powdery form and therefore the same effect is attained as by an increased percentage of the binder upon the castability of the composition and the mechanical strength of the shaped products. Thus, without the need for giving considerations in these respects, the overall oxidizer content can be increased, thus permitting much better control of the burning rate and the improvement of the specific thrust of the propellant. These effects can be obtained not only in the embodiment of the invention just described in which the blended solid oxidizer in granular form is mixed with a fuel binder before casting but also in such other embodiments as will be described later. In this invention, a special consideration must be paid to the orientation of the blended oxidizer grains during casting. If the ratio of the minimum length to the maximum length of the grain is 1:2 or less, there will be no adverse effect in most cases. In order to prevent settling during the casting

until hardening, the specific gravity of the blended solid oxidizer particles may be adjusted. Further it is possible to prevent non-uniform dispersion due to settling, by controlling the specific gravity, viscosity, and hardening rate of the liquid system composed of the fuel binder which is a dispersion medium, and the additives including solid contents. Regarding the effects of the shape of the blended solid oxidizer grains, it can be stated that the burning rate is increased with an increase in the diameter of the globules or balls, or with an increase in the rate of area of sheets oriented parallel to the direction of advance of the flame front, or with an increase in the rate of axis of cylinders or columns oriented parallel to the same.

As will be understood from the behavior of the blended solid oxidizer decribed above, the burning rate is improved even when the blended solid oxidizer is formed to cylinders or rods of length equal to the overall length of the propellant grain and then embedded throughout the fuel binding system. The burning rate of such propellant is higher than that attained by those formed of the ingredients of the same mixing ratio at random. If such rods are arranged across a propellant grain in such way that they may be densely located in the center, the resulting propellant grain even formed to burn from one end on, cigarette-fashion, will show a tendency of so-called conical burning as the combustion proceeds.

As described hereinabove, the blended solid oxidizer in accordance with the present invention is not used in powdery form but in one of various different shapes at least one millimeter in length, whereby adjustments in the burning rate and characteristics far better than have been achieved heretofore with the conventional powdery components, are possible through alteration of the shape, size, arrangement or mode of dispersion of the shaped oxidizer.

While the present invention is illustrated by the following examples, it should not be construed that the invention is in any way restricted thereto as well as to the embodiments described hereinbefore.

Example 1

A total of 50 parts by weight of a thoroughly mixed solid material in fine powdery form consisting of 38 parts by weight of ammonium perchlorate, 10 parts by weight of aluminum, and 2 parts by weight of copper chromite were pressed into tables 5 mm. in diameter and 3 to 4 mm. in thickness, which have a linear burning rate of 80 mm./sec. at a combustion pressure of 70 kg./cm.^{2}. The tablets of this blended solid (oxidizing) component were mixed with 50 parts by weight of a fuel binder consisting by weight of 12.5 parts of unhardened polyurethane, 34.5 parts of ammonium perchlorate, 2 parts of aluminum, and one part of copper chromite. The mixture was cast and hardened.

The thus formed propelliant grain had a burning rate of 47 mm./sec. at a combustion pressure of 60 kg./cm.^{2}, a specific thrust at atmospheric pressure of 237 sec. and a density of 1.8 g./cm.^{3}.

The above described fuel binder contained rather less amount of ammonium chlorate and alone it had a burning rate of 8 mm./sec. at a combustion pressure of 50 kg./cm.^{2}.

Example 2

A total of 50 parts by weight of a thoroughly mixed solid material in fine powdery form consisting of 38 parts of potassium perchlorate, 10 parts of aluminum, and 2 parts of copper chromite were pressed into tablets 5 mm. in diameter and 3 to 4 mm., in thickness. The tables had a linear burning rate of 200 mm./sec. at a combustion pressure of 70 kg./cm.^{2}. In the same manner as described in Example 1, the tablets were mixed with 50 parts of weight of a fuel binder and the mixture was cast and hardened. The linear burning rate of the thus formed propellant grain corresponded to 88 mm./sec. at a combustion pressure of 60 kg./cm.^{2}

What is claimed is:

1. In a composite solid propellant comprising preshaped particles of a mixure of
   (a) a solid inorganic oxidizer which is an ammonium, alkali metal or alkaline earth metal salt or perchloric or nitric acid,
   (b) a metallic fuel and
   (c) a burning-rate controller, said burning-rate controller being distributed throughout the mixture in a finely divided form, and said preshaped particles being at least one millimeter in length.

2. A composite solid propellant according to claim 1 wherein the metallic fuel is at least one member of the group consisting of aluminum, magnesium, beryllium, lithium and boron.

3. A composite solid propellant according to claim 1 wherein the metallic fuel is in the form of globules having a diameter of not more than 100 microns.

4. A composite solid propellant according to claim 1 wherein the metallic fuel is in the form of flakes having a diameter of not more than 100 microns.

5. A composite solid propellant according to claim 1 wherein the solid inorganic oxidizer is ammonium perchlorate, potassium perchlorate or potassium nitrate.

6. A composite solid propellant according to claim 1 wherein the burning-rate controller is carbon black, iron oxide, copper oxide, chromium oxide, copper chromite or an ammonium, alkali metal or alkaline earth metal salt of chromic acid, bichromic acid, perchromic acid or hydrofluoric acid.

7. A composite solid propellant according to claim 1 wherein the solid inorganic oxidizer comprises one to 95 percent of the total weight of the solid propellant.

8. A composite solid propellant according to claim 2 wherein the metallic fuel comprises one to 80 percent of the total weight of the solid inorganic oxidizer.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 9: change "entectoid" to --eutectoid--. Column 2, line 20: change "ue" to --be--. Column 2, line 42: change "age resistors" to --antioxidants--. Column 3, line 46: change "table to --tablets--. Column 3, line 55: change "propelliant" to --propellant--. Column 3, line 60: change "chlorate" to --perchlorate--. Column 4, line 5: change "tables" to --tablets-

SIGNED AND SEALED

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(SEAL)
Attest:

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