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SURFACE COMBUSTION INHIBITED PROPELLANT GRAINS AND PROCESSES FOR MAKING SAME

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This invention relates to an improved process for treating composite type solid propellant grains to inhibit surface combustion and to propellant grains having surface properties which resist surface combustion.

The term "composite" refers to two-phase propellant grains comprising an oxidizer intimately dispersed in a solid matrix of a plastic material which serves both as fuel and binder. The oxidizer is incorporated in the form of a finely divided solid which is insoluble in the matrix. In general, the oxidizer is water soluble, whereas the fuel and binder composition is water insoluble.

In order to obtain the desired ballistic properties and to prevent explosions caused by excessively high gas pressures, it is frequently necessary to control the rate of gas evolution by conditioning the grain in such a way that combustion travels along the grain in a predetermined course. For example, centrally perforated cylindrical grains designed to burn internally must be kept from igniting on the outside surface. Thus, it is often necessary to inhibit some of the surface to prevent ignition due to contact with the evolved hot gases. The usual practice hitherto has been to bond a covering layer of plastic to the surface of the grain by cementing or casting. This procedure has been subject to a number of important disadvantages. Flaws, due to imperfections in the seal or separation of the superimposed coating from the grain may result in explosions by permitting penetration of the hot gases. It is also difficult to cover sharp edges or corners of the grain. The application of inhibiting coatings is, furthermore, both time consuming and costly.

The object of this invention is to provide propellant grains of the composite type, the surface of which are inhibited against combustion without requiring the application of external coatings.

Another object is to provide processes for treating composite propellant grains whereby surface portions of the grain become resistant to combustion.

Other objects and advantages will become apparent from the following detailed description.

In general, our process comprises dissolving out the oxidizer adjacent the surface of the grain by immersion in a suitable solvent, thus leaving the surface portion of the matrix devoid of oxidizer and, therefore, resistant to combustion.

Any solvent in which the oxidizer is readily soluble, and the matrix is insoluble, and which may be readily removed by evaporation or drying, is suitable for our purpose. Since, generally speaking, the oxidizers employed in the manufacture of composite propellant grains are water soluble, whereas the matrix is water insoluble, water is our preferred solvent.

The water may be applied to the grain in liquid form or in the form of steam. The propellant grain is kept immersed in the aqueous medium until the oxidizer is leached out of the matrix to the desired depth. In general, a depth of about 20 to 100 mils is amply sufficient to inhibit surface combustion. However, the surface thickness of matrix devoid of oxidizer may be varied as desired simply by regulating the period of immersion in the solvent.

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The rate of solvent penetration into the grain increases with temperature so that for practical reasons of speeding up the leaching process it is desirable to use somewhat elevated temperatures, although this is not essential since the same results can be obtained at ordinary temperatures, albeit more slowly. We have found it most convenient to use water or steam at about 100° C. at which temperature from about 3 to 48 hours of immersion are ordinarily required, depending upon the inhibited surface thickness desired.

Each particle of oxidizer in the propellant grain is completely surrounded by the binding matrix. The solvent slowly penetrates the matrix and upon coming into contact with oxidizer particles quickly dissolves them, leaving the matrix intact. Thus, the penetrated portion of the matrix is rapidly freed from the oxidizer. At the same time, the relatively slow penetration of the insoluble matrix results in a sharp boundary gradient between matrix devoid of oxidizer and matrix containing the intimately dispersed oxidizer particles.

When the oxidizer has been leached out to the desired depth, the grain is removed from the solvent and dried.

Since the matrix remains intact and continuous throughout, separation of the combustion inhibited surface portion devoid of oxidizer from the combustible portions of the grain is impossible. Furthermore, the porosity produced by the removal of the oxidizer particles imparts desirable heat insulation properties.

Should it be desirable because of particular circumstances to inhibit only a portion of the propellant grain surface, this can readily be accomplished by covering the surface area which is to remain uninhibited with a removable, insoluble coating, as for example, a suitable tape or a thin coating of a water insoluble resin, prior to leaching. After the treated grain is dried the protective coating may be removed as by stripping or light sanding, leaving the protected surface portion uninhibited while the remaining surface area is resistant to surface combustion.

The surface combustion inhibited propellant grains of our invention possess many important advantages. There is no danger of explosion due to separation or imperfect sealing of a superimposed inhibiting coating. Grains having sharp edges or corners pose no difficulties since leaching of the oxidizer by the solvent occurs uniformly over the entire exposed surface of the grain. The treatment is very inexpensive and relatively rapid.

It will be understood that any composite type propellant grain may be treated according to our process to inhibit surface combustion so long as a suitable solvent is employed which readily dissolves the dispersed oxidizer and does not dissolve the binding matrix. For example, the oxidizer may be any suitable oxidizer known to and conventionally employed in the propellant art, such as perchlorates, nitrates, etc. The matrix may also be any of the compositions known to and employed in the art, including naturally occurring plastic materials, such as asphalt or the like, synthetic thermosetting and thermoplastic resins, etc.

The following examples are illustrative of our invention but it will be understood are in no way limiting:

Example I

A propellant grain comprising finely divided ammonium perchlorate dispersed in a matrix of plasticized polyvinyl chloride was immersed in boiling water for 6 hours and subsequently dried in air. The outer surface for a depth of about 25 mils was devoid of oxidizing particles with a well defined boundary gradient between matrix devoid of and matrix containing oxidizer. The flame of a similar grain impinging on the surface of the inhibited grain did not cause it to ignite.

Example II

A propellant grain comprising finely divided ammonium perchlorate dispersed in a matrix of plasticized polyvinyl chloride was immersed in boiling water for 21 hours and subsequently dried in air. The outer surface for a depth of about 42 mils was devoid of oxidizing particles with a well defined boundary gradient between matrix devoid of and matrix containing oxidizer. The flame of a similar grain impinging on the surface of the inhibited grain did not cause it to ignite.

Example III

A propellant grain comprising potassium perchlorate dispersed in a polyester-polystyrene matrix was treated as in Example I. A layer devoid of oxidizer was similarly formed.

Example IV

A propellant grain comprising ammonium perchlorate dispersed in a matrix of plasticized polyvinyl chloride was exposed to steam at 100° C. for 6 hours, and then dried in air. The matrix adjacent the surface for a depth of about 40 mils was free of oxidizer.

Example V

A propellant grain comprising ammonium perchlorate dispersed in a matrix of plasticized polyvinyl chloride was partially coated with a neoprene solution. After the coating was dried at 60° C., the grain was treated as in Example I. After drying, the neoprene coating was stripped off leaving an uninhibited surface area. The uncoated surface area of the grain which had been exposed to the leaching action of the water was devoid of oxidizer.

Although this invention has been described with reference to illustrative embodiments thereof, it will be understood by those skilled in the art that it may be embodied in other forms within the scope of the appended claims.

Having thus fully described our invention, we claim:

1. A solid propellant grain comprising a finely divided solid oxidizer intimately dispersed in a solid continuous matrix, said matrix serving as a fuel and binder for said oxidizer, wherein the portion of said continuous matrix adjacent the surface of said grain is substantially devoid of said oxidizer for an appreciable depth.

2. A solid propellant grain comprising finely divided solid oxidizer intimately dispersed in a solid continuous matrix, said matrix serving as fuel and binder for said oxidizer, wherein the portion of said continuous matrix adjacent a predetermined area of the surface of said grain is substantially devoid of said oxidizer for an appreciable depth.

3. A solid propellant grain comprising a water soluble, finely divided solid oxidizer intimately dispersed in a water insoluble solid continuous matrix, said matrix serving as fuel and binder for said oxidizer, wherein the portion of said continuous matrix adjacent the surface of said grain is substantially devoid of said oxidizer for an appreciable depth.

4. A solid propellant grain comprising a water soluble, finely divided solid oxidizer intimately dispersed in a water insoluble solid continuous matrix, said matrix serving as fuel and binder for said oxidizer, wherein the portion of said continuous matrix adjacent a predetermined area of the surface of said grain is substantially devoid of said oxidizer for an appreciable depth.

5. A process for inhibiting surface combustion of a solid propellant grain of the type comprising finely divided, solid oxidizer intimately dispersed in a solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises immersing said grain in a solvent, said oxidizer being soluble in said solvent and said matrix being insoluble in said solvent, said solvent serving to dissolve said oxidizer out of the portion of said matrix adjacent the surface of said grain and then drying said grain.

6. A process for inhibiting the surface combustion of

a predetermined surface area of a solid propellant grain of the type comprising finely divided solid oxidizer intimately dispersed in a solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises covering a predetermined surface area of said grain with a protective coating, immersing said grain in a solvent, said oxidizer being soluble in said solvent and said matrix and said protective coating being insoluble in said solvent, said solvent serving to dissolve said oxidizer out of the portion of said matrix adjacent the exposed surface of said grain, drying said grain and removing said protective coating.

7. A process for inhibiting surface combustion of a solid propellant grain of the type comprising a water soluble, finely divided, solid oxidizer intimately dispersed in a water insoluble solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises immersing said grain in water, said water serving to dissolve said water soluble oxidizer out of the portion of said matrix adjacent the surface of said grain and then drying said grain.

8. A process for inhibiting surface combustion of a solid propellant grain of the type comprising a water soluble, finely divided solid oxidizer intimately dispersed in a water insoluble solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises immersing said grain in steam, said steam serving to dissolve said water soluble oxidizer out of the portion of said matrix adjacent the surface of said grain and then drying said grain.

9. A process for inhibiting the surface combustion of a predetermined surface area of a solid propellant grain of the type comprising finely divided water soluble solid oxidizer intimately dispersed in a water insoluble solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises covering a predetermined surface area of said grain with water insoluble protective coating, immersing said grain in water, said water serving to dissolve said oxidizer out of the portion of said matrix adjacent the exposed surface of said grain, drying said grain and removing said protective coating.

10. A process for inhibiting the surface combustion of a predetermined surface area of a solid propellant grain of the type comprising finely divided water soluble solid oxidizer intimately dispersed in a water insoluble solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises covering a predetermined surface area of said grain with a water insoluble protective coating, immersing said grain in steam, said steam serving to dissolve said oxidizer out of the portion of said matrix adjacent the exposed surface of said grain, drying said grain and removing said protective coating.

11. A process for inhibiting surface combustion of a solid propellant grain of the type comprising a water soluble, finely divided solid oxidizer intimately dispersed in a water insoluble solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises immersing said grain in water, maintaining the grain in contact with said water until the oxidizer is dissolved out of the portion of the matrix adjacent the surface of the grain for a predetermined depth, and then drying said grain.

12. A process for inhibiting surface combustion of a solid propellant grain of the type comprising a water soluble finely divided solid oxidizer intimately dispersed in a water insoluble solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises immersing said grain in steam, maintaining the grain in contact with said steam until the oxidizer is dissolved out of the portion of the matrix adjacent the surface of the grain for a predetermined depth, and then drying said grain.

13. A process for inhibiting surface combustion of a solid propellant grain of the type comprising a water soluble, finely divided, solid oxidizer intimately dispersed in a water insoluble solid matrix, said matrix serving as

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fuel and binder for said oxidizer, which comprises dissolving said water soluble oxidizer out of the portion of said matrix adjacent the surface of said grain by immersing said grain in water which is at a temperature of about 100° C. and then drying said grain.

14. A process for inhibiting surface combustion of a solid propellant grain of the type comprising a water soluble, finely divided, solid oxidizer intimately dispersed in a water insoluble solid matrix, said matrix serving as fuel and binder for said oxidizer, which comprises dissolving said water soluble oxidizer out of the portion of said matrix adjacent the surface of said grain by immersing said grain in steam which is at a temperature of about 100° C. and then drying said grain.

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