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EXPLOSIVES

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This invention relates to explosives and particularly to a method of molding granular propellant powder grains into consolidated charges.

Smokeless powder charges have traditionally been used as the propelling charge in small arms ammunition and also in artillery ammunition. The size of the grain generally increases with the size and weight of the cartridge. More recently, such smokeless powder charges have also been used as components in gas generating cartridges. They are particularly useful as ignition and booster charges for transmitting the flame from the primer to the main charge. In such capacities, they must be functionally located with relation to the other components of the gas generating device. To obtain such positioning, the propellent powder grains are normally supported by some structural means such as trays, bags, combustible containers, and the like. Thus, the limitations on the utility of loose granular propellent charges has long been recognized and it has also been realized that these limitations could be minimized or substantially reduced by the provision of a consolidated self-contained powder charge that could be handled as a unit but would have the ballistic properties of a granular propellent.

Prior to the advent of the present invention, processes for such consolidation of propellent powder granules have met with only a modicum of success. These previous attempts have involved the application of pressure to substantially dry powder or to powder mixed with a solvent. When dry molding methods were used, the resultant molded powder charges crumbled readily because of the lack of cohesion between the individual granules. On the other hand, when grains were wet with a solvent for them, the major portion of the solvent was absorbed by the immediately adjacent grains. This resulted in the complete loss of grain identity in the high solvent area with little or no solvent reaching the remaining portions of the charge. Thus, the resultant charges were not uniform and upon combustion could not burn as a normal progressive burning granular propellent charge.

It is, therefore, an object of this invention to provide a new and novel method for consolidating granular propellent charges that overcomes the disadvantages of the prior art processes. A more specific object of this invention is to provide a process of making consolidated propellent charges having the ballistic properties of a granular propellent charge.

These and other objects are accomplished in accordance with this invention, generally speaking, by subjecting to pressure a charge of propellent powder grains surface coated with a solvent for the propellent powder base dispersed in an aqueous medium, and subsequently removing the solvent and aqueous medium therefrom. The solvent must be substantially uniformly dispersed throughout the aqueous non-solvent medium. When a water miscible solvent is employed, it is dissolved in the aqueous medium. However, water immiscible solvents can also be utilized by suspending them in water in the form of a stable emulsion.

Powder grains of any desired shape can be utilized as the starting material for the manufacture of consolidated charges in accordance with this invention. The particular

shape of the grains employed will depend to some extent upon the type of charge desired. While extruded or disc powder grains can be used, it is preferred to employ spherical powder grains of the type described in U.S. Patent 2,160,626 issued to Harold Schaefer. When such spherical grains are rolled and partially flattened, they provide a particularly advantageous starting material for the process of the present invention. The powder grains can be formed of any of the conventional gelatinizable bases. These bases include, for example, gelatinized nitrocellulose, nitrocellulose and nitroglycerin, nitrocellulose with accelerators and/or deterrents, polyvinyl nitrate, nitrostarch and other gelatinizable polynitro compounds.

Any volatile solvent for nitrocellulose or the other gelatinizable polynitro propellent powder bases can be used. The term "volatile" as used herein designates a solvent having a boiling point less than that of water; that is, less than 100° C. Volatile solvents must be utilized in order that they may be readily removed from the consolidated powder charges. The solvent must be miscible or emulsifiable with water to insure its uniform distribution throughout the aqueous medium. Because of ease of operation and economy, it is preferred to utilize solvents that are highly soluble or completely miscible with water. Acetone is the preferred water miscible solvent but other water miscible solvents, such as methyl ethyl ketone, dioxane, ethylene glycol, dimethyl ether, diethylene glycol, and the like can also be used. Water immiscible solvents are used in the form of stable emulsions. Such solvents include ethyl acetate, butyl acetate, methyl acetate, isopropyl acetate, methyl isobutyl ketone, cyclohexanone, and the like. The stable emulsion can be prepared by standard procedures utilizing sulfonated Turkey red oil, non-foaming detergents, sodium dioctyl sulfo succinate, glyceryl monostearin, and the like. The solvent system used can be a single compound or a mixture of two or more solvents. Thus, a number of binary solvent systems including dioxane-ethyl alcohol, methyl ethyl ketone-benzene, ethyl ether-ethyl alcohol, and methyl furan-ethyl alcohol are also applicable. Other nitrocellulose solvent systems are also suitable provided they are more volatile than water and are water miscible or water emulsifiable.

The weight proportions of the powder, solvent and water must be maintained within prescribed limits to insure the formation of satisfactory self-contained consolidated charges. While these proportions are somewhat dependent upon the particular propellent powder base and solvent system employed, it has been found that the amount of volatile solvent used must be maintained between about 12% and abou 75% of the weight of the powder. When less than about 12% solvent is used, the resultant consolidated charge has no structural strength, it is quite crumbly and is subject to the development of severe surface cracking upon curing. If the amount of solvent employed exceeds about 75% of the weight of the powder, the finished molded grain prior to curing is too soft to handle. Also, the molded grain is difficult to cure and exhibits excessive and non-uniform shrinkage upon solvent removal. In addition, upon firing, it does not exhibit the ballistic properties of a granular propellent charge. The amount of water employed as a carrier for the solvent is somewhat less critical but must be maintained within limits to provide an operable and facile process. Thus, the amount of water present in the process can vary between about 15% and about 100% based on the weight of the powder. When less than about 15% water is used, difficulty is experienced in obtaining a uniform product. While amounts of water in excess of 100% of the weight of the powder can be

used, they render the process cumbersome and serve no useful purpose.

Standard molding operations and apparatus can be used in compressing or consolidating the granular propellent charge after it has been wet by the water carrying the solvent. For most operations, it is preferred to consolidate the charge under a pressure of about 5,000 pounds per square inch for about 2 seconds. However, the pressure can vary between about 1000 pounds per square inch and 10,000 pounds per square inch with molding times varying between about 1 second and 20 seconds, depending upon the particular type of powder being consolidated and the size and configuration of the final product. The consolidating operation is preferably carried out at ambient or room temperatures but can be executed at any desired temperature provided only that the solvent and the water are in liquid form.

The solvent and water are preferably removed from the consolidated charge by subjecting it to elevated temperatures not appreciably above the boiling point of water. While elevated temperatures are preferred in order to expedite curing, the consolidated charges can also be cured more slowly at room temperature or at more slightly elevated temperatures. The time required for this curing is dependent upon the size and configuration of the charge and also upon the amount and properties of the solvent and the weight of the water used.

The manner in which the objects of the present invention are achieved will be more readily understood when the following specific example of a preferred embodiment thereof is read. In this example and throughout the specification, all proportions are expressed in parts by weight.

About 15 parts of spherical powder grains of the type described in U.S. 2,160,626 were provided. This powder consisted predominantly of nitrocellulose and contained about 12% nitroglycerin, 1% diphenylamine and 3% diphenylphthalate. These spherical grains were of such a size that they passed through a screen having openings of about 0.025 inch and were retained on a screen having openings of 0.020 inch. The powder was then rolled to a web of about 0.009 inch. After rolling, the powder was placed in a suitable mixer and about 12 parts of a 50% solution of acetone in water added thereto. The powder and solution were mixed for about one minute at which time the surfaces of the powder grains were substantially uniformly coated with the aqueous acetone solution. The resultant mixture was then transferred to a pelleting press having a circular die cavity about ¾ of an inch in diameter. A pressure of about 5,000 pounds per square inch was then applied for about 2 seconds. At the end of this time, the resultant consolidated charge was removed from the mold cavity and cured at about 100° C. for approximately 2 hours. The consolidated charge thus prepared was rigid and self-contained with a thickness of about 3/32 of an inch and a diameter of about ¾ of an inch. While charges made in this fashion appear substantially solid, the individual powder grains making up the charge have not lost their identity. When subjected to the blast of conventional primers, the charges fragment to provide uniform burning characteristics of a loose powder.

The most advantageous characteristic of the consolidated propellent powder charges prepared in accordance with this invention is that upon combustion they burn as a loose granular charge in which the surface of each original grain is ignited rather than as one large charge in which the combustion is limited to the surface of the mass. In order to illustrate the burning characteristics of the consolidated charges, ten consolidated discs prepared in accordance with the above preferred example were utilized as booster charges to transmit energy from the primer to the main charge in a gas generating cartridge of the type shown in the co-pending application of C. O. Williams et al., Serial No. 572,177, filed March 15, 1956, now U.S. Patent No. 2,974,592, issued March 14, 1961. As shown in this co-pending application, the cartridges are fired in pairs and the gas generated thereby is transferred to mechanical energy by means of a piston. These were compared with similar cartridges using as a booster a similar charge of the loose powder used in making up these consolidated charges. Upon firing, the thrust in pounds, the pressure in pounds per square inch, and the reaction time in seconds were recorded. The performance of the novel consolidated powder charge discs which burn like loose powder and the loose powder charges is tabulated below:

Molded Grain, 1.5 Grams of Powder				Loose Powder, 1.5 Grams of Powder			
Shot	Thrust	Pressure	Reaction Time	Shot	Thrust	Pressure	Reaction Time
1	22,700	13,600	.018	6	24,500	14,800	.018
2	24,500	14,400	.018	7	23,200	13,600	.018
3	24,700	14,700	.018	8	25,700	16,000	.017
4	21,300	12,300	.019	9	25,200	16,100	.017
5	22,500	11,900	.019	10	24,000	16,300	.017

The reaction time set forth in the above table is the time required for primer ignition, ignition of the booster, the main propellent charge, and movement of the piston through its stroke. It will be noted that there is only a variation of 2 milliseconds between all 10 shots. This is well within the realm of experimental error. Likewise, the thrust developed by the consolidated grains varied between 21,300 and 24,700 while that developed by the loose powder charge ranged between 23,200 and 25,700. Also, the pressures generated by the consolidated and loose charges are comparable. By contrast, when a completely homogeneous charge of the same size and shape and formed of the same components is fired in the same cartridge, the thrust and pressure are considerably lessened and the reaction time is several times longer. This clearly illustrates that the consolidated charges of the present invention have the ballistic properties of a granular explosive rather than of a conventional solid charge of propellent.

While the above example is concerned primarily with the preparation of consolidated charges in the form of discs, it will be readily appreciated that the charges can be made of any convenient size or shape. Also, the consolidated charges can be readily employed as evanescent closures for various types of explosive and gas generating devices. This invention also contemplates the formation of self-contained propellent charges. In accordance with this modification, the conventional cartridge case can be dispensed with and the projectile and priming means connected to opposite ends of the charge.

From the above description, it is clear that this invention accomplishes its objects and provides a novel process for producing a consolidated powder charge having the ballistic properties of a granular propellent.

Having now described the invention, what is claimed is:

1. A method of preparing a one piece propellent powder charge that burns as a granular propellent which comprises providing a multiplicity of grains of a gelatinized propellent powder base substantially free of volatile solvent, mixing the grains with an aqueous medium containing a volatile solvent for the gelatinized propellent powder base until the surface of the grains is uniformly coated, the amount of the volatile solvent in the aqueous medium being substantially less than that required to dissolve the propellent powder grains, subjecting the multiplicity of grains coated with the aqueous medium to pressure until they adhere together, forming a consolidated body of individual grains with each grain maintaining its individual identity, and subsequently drying the consolidated powder charge.

2. The method of claim 1 in which the volatile solvent is dissolved in the aqueous medium.

3. The method of claim 1 in which the volatile solvent is uniformly dispersed in the aqueous medium.

4. A method of preparing a one piece propellent powder charge that burns as a granular propellent which comprises subjecting gelatinized substantially solvent-free propellent powder grains, whose surface is coated with an aqueous medium having a volatile solvent for the grain uniformly dispersed therethrough, to pressure until the grains are cemented together while maintaining their individual identity, and subsequently removing the aqueous medium having a volatile solvent therefrom, the amount of the volatile being substantially less than that required to dissolved the propellent powder grains.

5. The method of claim 4 in which the individual propellent powder grains are substantially spherical.

6. The method of claim 4 in which the weight of solvent is between about 12 percent and about 75 percent of the weight of the powder and the weight of the water is between about 15 percent and about 100 percent of the powder.

7. A method of preparing a one piece propellent powder charge that burns as a granular propellent which comprises providing grains of a gelatinized propellent powder base substantially free of volatile solvent, mixing the grains with an aqueous dispersion of a volatile solvent for the propellent powder base until the surfaces of the grains are substantially coated with the dispersion, the amount of volatile solvent in the aqueous dispersion being less than that required to dissolve the propellant grains, placing the coated grains in a mold, subjecting them to pressure until the grains adhere together while maintaining their individual identity, and removing the dispersion therefrom.

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