

"Propellant for base-bleed gas generators and process for its manufacture".

Description

This invention relates to a propellant for base-bleed gas generators, i.e. for generators comprising a gas generator charge in order to increase the range of projectiles which are equipped therewith and containing one or more granular or pulverulent solid substances, at least one of which is an oxidant, and a binder, as a propellant of this type.

The term base-bleed gas generator refers to a propellant device which generates gas intended to increase the range of projectiles which are so equipped, without this effect being produced by active acceleration of the projectile. It is already known that in order to increase the range of projectiles launched by artillery weapons, such as 155 mm shells for example, a propellant charge is placed in the chamber at the base of the projectile. Through its combustion, this propellant charge produces an increase in the acceleration of the projectile. A disadvantage of this system is that the increased acceleration significantly decreases the accuracy of the shot. Added to this is the disadvantage that there is an appreciable increase in the weight of the projectile due to the combustion chamber in the base of the projectile, such that the increase in range is not proportional to the additional energy consumption. Also, as the length of these projectiles cannot be increased inordinately for ballistic reasons, it is inevitable that the said propellant charge is incorporated to the detriment of the useful volume of the projectile. Furthermore, these

accelerating propellant charges are relatively complicated and therefore their cost price is rather high.

Partly because of these disadvantages and partly because experience has shown that a relatively weak powered active acceleration is sufficient in most cases to produce an appreciable increase in the range of the projectile, the use of base-bleed generators is restricted to increasing the range of the projectiles. In such cases, the combustion gases only escape from the combustion chamber of the projectile under a relatively low excess pressure of between 0.01 and 2 MPa and at a combustion speed which varies between 0.5 and 5 mm/second.

Under these conditions the active acceleration produced by the combustion of the propellant charge is practically zero. The propellant charge will only ignite after the projectile has left the gun and the combustion gases which escape from the chamber in which the propellant charge is ignited are restricted to filling the void which is formed at the rear of the projectile due to aerodynamic flow. It is known that this void retards the movement of the projectile and thus reduces its range. The filling of this void by the combustion gases which escape from the projectile eliminates to a great extent the negative aerodynamic forces directed towards the rear which act as a braking force on the projectile. The great advantage which this system has over the use of active accelerating propellant charges is that it allows an increase of approximately 30 % in the range of projectiles at an appreciably lower cost. Furthermore, since the increase in the range of the projectile is obtained only by the filling of the aforementioned aerodynamic vacuum and thus without active acceleration, the firing accuracy is significantly better than when reaction-type propellant charges are used.

The propellants used until the present time in base-bleed gas generators are used exclusively in the form of ready to use solid moulded blocks, and in the majority of cases

the components from which they are manufactured are unsuitable for storage. Base-bleed gas generators are described in Belgian patent no. 834 903.

Propellant masses or charges for base-bleed gas generators are manufactured using known processes in the following way. An oxidant, such as ammonium perchlorate, and possibly other solid substances such as aluminium as the combustible or others, are mixed with a binder in liquid form, such as butadiene for example, so as to form a highly viscous mass or paste, which is then, possibly after addition of a hardener, placed in a mould and left to harden for 4 - 7 hours at a temperature of 50 - 80 °C. A disadvantage of this known process is that the mixture from which the charge is manufactured, i.e. the mixture of the oxidant and the binder, does not keep and cannot therefore be stored because of both the spontaneous separation of the mixture and the danger of hardening. Another disadvantage is that the filling of the moulds with the viscous mixture for the shaping of the very small propellant charges is a very laborious process and, because of this, is not very cost effective. It is therefore preferable for the mixture to be moulded in the form of large blocks which are then cut into smaller blocks and then turned to produce their definitive shape. Taken all in all, this is also very laborious and not very cost effective.

This invention is intended to remedy the above-mentioned disadvantages in the known processes for the manufacture of propellant charges of the type concerned and for this purpose relates to the design and development of a new process which is suitable for the production of mixtures intended for use in the manufacture of propellant charges for which there are no problems of conservation and which may be easily stored either to be sold as intermediate products or in anticipation of their ultimate conversion. The process as specified in the invention for the manufacture of propellant masses is characterized in that the binder is a thermoplastically deformable elastomer and that this elastomer, with the addition of solvents,

is homogeneously mixed with the solid ingredients and finally deposited on these ingredients by elimination of the solvents so as to form a granular product.

Another object of the invention consists of making available to interested parties a propellant mass of the relevant type which is free from the above-mentioned disadvantages and which may be easily conserved for ultimate use as a propellant charge in the base-bleed gas generators of projectiles.

With the intention of fulfilling the above-mentioned objectives, the mixture as specified in the invention is characterized in that its binder is a thermoplastic elastomer, that it is in a granular form and that the granules of the mixture are encapsulated in this thermoplastic elastomer.

Finally, the invention also involves a process for the manufacture of propellant charges for base-bleed gas generators, i.e. for generators comprising a gas generator charge in order to increase the range of projectiles which are so equipped, containing one or more granular or pulverulent solid substances, at least one of which is an oxidant, and a binder, characterized in that the mixture of the said solid granular ingredients and the said binder in the form of a thermoplastic elastomer is moulded at a high temperature and the body thus obtained is equipped with an isolating jacket.

The solvents used in the application of the process as specified in the invention are trichloromethane and trichlorethylene. The oxidant is, for example, ammonium perchlorate, ammonium nitrate or a similar compound.

The essential point of the invention is thus that the solid ingredients of the propellant masses in question are incorporated into them by encapsulation using a thermoplastic elastomer, which enables the mixture obtained to be conserved with a view to its ultimate use in the manufacture of bodies of any appropriate shape whatsoever at high temperature and under high pressure, which is made possible by the presence of this thermoplastic elastomer.

The advantages of the solution as specified in the invention are the following. The propellant mass may easily be manufactured in the form of granules for purposes of storage and in anticipation of its ultimate use. The granular ingredients may easily be mixed and they are easily dispersed in a solvent without any problem. The same applies to the ultimate conversion of the mixture thus prepared into bodies of the appropriate shape, which itself no longer poses any problems. Furthermore, any danger of separation of the solid ingredients, such as the oxidant or the binder, is eliminated because of the fact that the conversion of the granular mixture into a propellant charge under compression precludes any danger of sedimentation. This is in contrast to the usual process based on the use of liquid binders, in which the risk of separation due to sedimentation is always present.

According to a preferred method of application of the invention, the thermoplastically deformable elastomer is a triple-block polymer, such as in particular a copolymer of butadiene and styrene or of isoprene and styrene in regularly arranged groups. The best results are obtained with thermoplastic elastomers which are soluble in the above-mentioned solvents.

Another preferred method of application of the invention provides for the elimination of the solvent by a process of evaporation. The elimination of the solvent results in the thermoplastically deformable elastomer being deposited on the granules of the solid ingredients and in particular the oxidant granules in such a way that, according to this method of application, the elimination of the solvent and the deposition of the elastomer occur simultaneously. According to a third preferred method of application, these two processes, i.e. the deposition of the elastomer and the elimination of the solvent, occur sequentially, the elastomer being precipitated onto the particles of the solid ingredients by the addition of a nonsolvent liquid and the mixture of the solvent and the nonsolvent liquid then being eliminated by aspiration.

This method of application is thus characterized in that the elastomer is first precipitated in the suspension in such a way as to be deposited on the granules of the solid substances and the mixture of liquid substances present in the mixture is then eliminated by aspiration, for example by a vacuum filter. The nonsolvent liquid is acetone, for example.

Another method of application specifies that the mixture of solid substances in the mixture as specified in the invention, apart from the oxidant, also contains other high-energy substances in order to regulate the rate of combustion of the propellant charges manufactured from the mixture. For example, these may be be nitroguanidine, guanidine nitrate, cyclonite, octogen or pentaerythritol tetranitrate.

In addition to combustion regulators and stabilizers added at any stage of its preparation, the mixture as specified in the invention may also contain a plasticizer for the binder, such as trioctylphosphate.

All the ingredients of the mixture as specified in the invention are mixed preferably at a high temperature and in any case the definitive homogenous mixing at the last stage must occur at a temperature of about 80 °C.

In order to eliminate the last traces of solvent, as specified in one characteristic of the invention, it is recommended that the granular preparation is allowed to undergo a final drying process which is continued until its volatile component content is less than 0.1 %.

Other characteristics and advantages of the invention become apparent from the following detailed description of an example of an application of the process in question and an example of the mixture prepared by this process and intended for the manufacture of propellant charges.

According to this method for the application of the invention, 550 g of ammonium perchlorate granules (oxidant) and 250 g of nitroguanidine granules (added combustible) are homogeneously mixed in a double-action horizontal mixer. A 10% solution of butadiene and styrene copolymer in trichlorethane is added to the mixture obtained. The total quantity of butadiene and styrene copolymer thus added is approximately 180 g. The mixture of solid granular substances and the 10% solution of butadiene and styrene copolymer in trichlorethane thus obtained is then made homogeneous by forced mixing. After addition of 20 g trioctylphosphate as a plasticizer, the suspension thus obtained is again mixed at a temperature of about 80 °C, after which the solvent is eliminated by vacuum evaporation.

Another process for the elimination of the solvent, which differs from elimination by evaporation, consists of the addition of a nonsolvent liquid, such as acetone, to precipitate the butadiene and styrene copolymer solution and to deposit it on the granules of the solid ingredients in the dispersion, after which the trichlorethane and acetone mixture is removed from the solid ingredients by vacuum filtration.

In both cases a granular mixture is obtained in which the granules are coated with a layer of binder, i.e. a layer of butadiene and styrene copolymer.

The last traces of solvent still present in the granular mass of granules encapsulated in copolymer are eliminated by continuous drying for at least 12 hours at a temperature of about 50 °C which, in view of the relatively low quantities present obtained in the example of the application described here, may be carried out in a lacquer dryer. After this drying process, the volatile substances content of the mixture will be less than 0.1%. The granular mixture as specified in a specific method for the application of the invention consists of solid ingredients such as ammonium perchlorate as an oxidant and nitroguanidine as an added combustible and combustion rate regulator. The granules of the mixture are

encapsulated in a layer of a butadiene and styrene copolymer as a binder with a low trioctylphosphate content as a plasticizer. The percentages of the various preparation compounds are as follows : 55% ammonium perchlorate, 25% nitroguanidine, 2% trioctylphosphate and 18% butadiene and styrene or isoprene and styrene copolymer.

The mixture as specified in the invention intended for the manufacture of propellant charges is suitable for practically unlimited storage with no danger of deterioration of its properties. It is recommendable that it should be mixed again to restore homogeneity before its ultimate use. As specified in the invention, it is suitable for the manufacture of propellant charges for base-bleed gas generators by compression in a mould and enclosure in an isolating jacket, applied either by compression in the mould or by subsequent application after removal from the mould. The bodies thus obtained will have, for example, a length of 130 mm and a diameter of 120 mm and be equipped with an axial tube of 43.5 mm diameter intended for the evacuation of the gases formed by combustion of the propellant charge in a steady stream during the flight of the projectile thus equipped. The propellant charge may be composed of two half cylindrical bodies, each fitted with a longitudinal groove which is semicircular in cross-section, in such a way that the two grooves of the two half-cylindrical bodies joined together in the gas generator form the above-mentioned gas evacuation tube.

Given below are some specific data relating to a base-bleed gas generator carrying a propellant charge as specified in the invention and intended for installation in projectiles in order to increase the range : gas flow pressure : +/- 0.22 MPa at a combustion rate of 1.11 mm/second ; 0.89 MPa at a combustion rate of 3.0 mm/second ; 1.37 MPa at a combustion rate of 3.4 mm/second, etc.

The maximum tensile strength of the product as specified in the invention is 0.51 N/mm^2 at 20°C and an elongation rate of 50 m/second, with a corresponding elongation of more than 150%. Relative density at $100 - 140^\circ\text{C}$ at a pressure of 20 - 50 MPa is $\pm 1.52 \text{ g/cm}^3$. It is evident that the characteristics of the invention described in the preceding lines and in the following claims are applicable jointly and severally to all possible combinations of the methods of application of the invention.

Claims



1. Process for the manufacture of propellants or propellant bodies for base-bleed gas generators, i.e. for generators comprising a gas generator charge to increase the range of projectiles so equipped and containing one or more granular or pulverulent components, at least one of which is an oxidant, and a binder, with the characteristic that this binder is a thermoplastic elastomer, that the latter contains solvents as additives and is homogeneously mixed with the solid ingredients, and that the solvent is eliminated from the mixture, thus producing a solid granular product.
2. Process as specified in claim 1, with the characteristic that the aforementioned thermoplastic elastomer is a triple-block polymer.
3. Process as specified in claim 2, with the characteristic that the aforementioned triple-block polymer is a copolymer of butadiene and styrene or isoprene and styrene with a regularly arranged structure.
4. Process as specified in claim 1, with the characteristic that the aforementioned thermoplastic elastomer is a polyurethane.
5. Process as specified in any of the preceding claims, with the characteristic that a 10% solution of the aforementioned thermoplastic polymer is mixed with the solid ingredients.
6. Process as specified in any of the preceding claims, with the characteristic that the solvent is eliminated by vacuum evaporation.
7. Process as specified in any of preceding claims 1 - 5, with the characteristic that the aforementioned elastomer is precipitated onto the solid components by the addition of a nonsolvent liquid and that the remaining mixture of solvent and nonsolvent liquid is eliminated by suction.
8. Process as specified in any of the preceding claims, with the characteristic that other solid substances, which are high-energy chemical compounds, are added to the oxidant in order to form a mixture of solid substances.



9. Process as specified in any of the preceding claims, with the characteristic that combustion regulators or moderators are added to the mixture of ingredients of the mass concerned.

10. Process as specified in any of the preceding claims, with the characteristic that plasticizers are added to the suspension obtained from the mixing of the solid substances and the thermoplastic elastomers.

11. Process as specified in any of the preceding claims, with the characteristic that chemical stabilizers are also added.

12. Process as specified in any of the preceding claims, with the characteristic that the definitive mixture is prepared at a high temperature.

13. Process as specified in claim 12, with the characteristic that the definitive mixture is prepared at a temperature of about 80 °C.

14. Process as specified in any of the preceding claims, with the characteristic that after elimination of the solvent by decantation or aspiration the granular mass is dried at a high temperature.

15. Process as specified in claim 14, with the characteristic that the granular mass is dried until its volatile components are less than 0.1%.

16. Process as specified in claim 14 or 15, with the characteristic that the drying process takes place at a temperature of about 50 °C.

17. Process as specified in any of claims 14 - 16, with the characteristic that the drying process is continued for at least some 12 hours.

18. Propellant for base-bleed gas generators, i.e. generators equipped with a gas generator charge containing one or more solid granular or pulverulent substances, at least one of which is an oxidant, and a binder, with the characteristic that the binder is a thermoplastic elastomer, that the propellant is in the form of a granular mass and that the solid particles are encapsulated by the aforesaid thermoplastic elastomer.

19. Propellant as specified in claim 18, with the characteristic that the thermoplastic elastomer is a triple-block polymer.



20. Propellant as specified in claim 18, with the characteristic that the triple-block polymer is a copolymer of butadiene and styrene or isoprene and styrene with regularly arranged groups of butadiene and styrene or isoprene and styrene.

21. Propellant as specified in claim 18, with the characteristic that the aforesaid elastomer used as a binder is a thermoplastic polyurethane.

22. Propellant as specified in any of claims 18 - 21, with the characteristic that in addition to the aforementioned oxidant, it also contains high-energy chemical compounds and/or plasticizers and/or stabilizers.

23. Process for the manufacture of propellant charges for base-bleed gas generators, i.e. for generators comprising a gas generator charge to increase the range of projectiles so equipped and containing one or more granular or pulverulent components, at least one of which is an oxidant and a binder, gas generator charge which is in particular a propellant as specified in one of the preceding claims 18 - 22, with the characteristic that the mixture of the aforementioned solid granular substances and the aforementioned thermoplastic elastomer acting as a binder is moulded at a high temperature and equipped with an isolating jacket.

24. Process as specified in claim 23, with the characteristic that the aforementioned propellant charges are obtained in the form of bodies of appropriate shape and size by extrusion and longitudinal cutting of the extrusion thus obtained.

25. Process as specified in claim 23, with the characteristic that the propellant charges are obtained in the form of bodies of appropriate shape and size by high temperature moulding.

26. Process as specified in claim 25, with the characteristic that the moulding process is performed at a temperature of 100 - 140 °C.

27. Process as specified in any of claims 24 - 26, with the characteristic that the aforementioned moulding process is performed under a pressure of 20 - 50 MPa.