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REGULATION OF BURNING SPEED FOR THE GRANULES OF HIGH ENERGY MATERIALS IN MILITARY FIELD (SINGLE-BASED PROPELLANT) USING ABSORPTION OF CAMPHOR METHODS

Pham Quang Hieu[1, *], Pham Van Toai[1], Chu Chien Huu[2], Duong Ngoc Co[1]

[1]*Institute of Propellants and Explosives, 192 Duc Giang Str, Long Bien District, Ha Noi*

[2]*Institute of Chemistry and Materials, 17 Hoang Sam Str, Cau Giay District, Ha Noi*

[*]Email: *hieuphus@gmail.com*

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ABSTRACT

As launchers for artillery weapon, grains were used that have energy in military equipment (also known as the single-based propellant). Each type of artillery weapon has a special requirement for muzzle velocity and pressure in which for the ammunition used for weapon with long barrel and high power, the term "increasing the efficiency of propellant" means, it is extremely important to improve the muzzle velocity of the projectile while maintaining maximum pressure in the barrel. This article presents one of the key approaches to "increasing the efficiency of propellant" by regulation the grain velocity of the initial particles of propellant by absorbing camphor on their surfaces (phlegmatic propellant).

Keywords: efficiency of propellant, phlegmatic propellant, absorbing camphor.

1. INTRODUCTION

The speed of projectile is clearly showed throwing the internal ballistics. Relating of parameters of maximum throwing speed V_{max}, muzzle velocity V_o and characteristics of the artillery fire are [1]:

$$V\max = \sqrt{\frac{2}{\varphi} * \frac{f}{\theta} * \frac{\omega}{m}} \quad (1)$$

$$Vo = \sqrt{\frac{2S}{\omega m}} * \int_0^L Pd(l) \quad (2)$$

where: m- the projectile mass, kg; φ- coefficient of supposed, θ- coefficient of adiabatic, f- force of propellant, kgs.dm/kg , ω- propellant mass, kg; S- section of barrel artillery, dm^2; l- length of artillery, dm; P- pressure in artillery, kg/cm^2.

From the above formula, it is seen that the speed of the projectile can be improved by the following ways [1]:

+ Method 1: Change the propellant composition in the direction of raising the propellant force (f) or reducing the molecule mass of the combustion product, or at the same time both;

+ Method 2: Increase the relative ratio between the propellant mass and the projectile mass;

+ Method 3: Control of the gassing process, in order to increase the progressivity of combustion of the powder charge (Figure 1 indicates 2 types of the pressure distribution curve along the barrel channel of non- phlegmatic propellant and phlegmatic propellant).

However, for long barrel artillery, in conditions of requiring a Pmax limited value while barrels, propellant and projectile mass are constant, the firing speed of the projectile would increase only in the case of optimizing firing process of the propellant (i.e., in the third way). In ideal conditions, the pressure should be kept at the maximum value from the beginning of the moved projectile to the end of the combustion [1]. To do this, the propellant must be designed and manufactured according to the principle of increased fire (surface area increased fire).

Figure 1 shows the graph of the pressure curve in the cylinder as the length of the shotgun. For the non-phlegmatization of gunpowder, the combustion process is very rapid, and the pressure reaches a maximum value in extremely short times. As for the phlegmatized powder, the combustion was slower, which led to a balance of pressure with the volume of the combustion chamber created by the warhead. Therefore, the maximum pressure in the frame remains from the beginning of the projectile to the end of combustion. Thus, the purpose of the article is to slow down the process of burning the original powder, by phlegmatizing, using camphor as a phlegmatized agent.

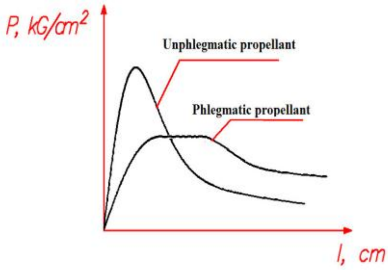

Figure 1. Graph P(l) pressure follows the length barrel.

2. EXPERIMENT

2.1. Propellants (semi-finished)

The norminal composition was diphenylamine 1.4-1.6 %, ethanol and diethyl ether 0.6 - 1.0 %, moisture 0.3-0.6 %, xerezin 2.0...3.2 % and the remainder nitrocellulose (NC 12.9... 13.1 %). The mean length of the grains was 3.0÷3.4 mm and the maximum perforation diameter 0.2 mm. The phlegmatics was camphor ($C_{10}H_{16}O$) and solvent was ethanol (assay ≥ 98 %).

2.2. High-performance liquid chromatography

Used to analyze camphor content in propellants.

2.3. High-pressure measuring equipment

Used to analyze coefficient of burning rate u_1 of propellants. The method of determining coefficient of burning rate u_1 by the B214 signal converter and the B180 high pressure bomb is based on the relational expression [2]:

$$u_1 = e_1 / \int_0^{t_{max}} P\mathrm{d}t \qquad (3)$$

where: u_1- coefficient of burning rate, mm/(bar.s); e_1 – hafl thickness of the burning of propellants grains, mm; P – pressure, kg/cm^2; t – time of burning rate, ms; t_{max} – burning time reaching the maximum pressure, ms.

2.4. Equipment for manufacturing phlegmatic propellant [3]

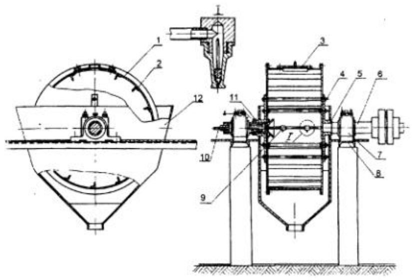

Figure 2. Equipment for manufacturing phlegmatic propellant
1- cylinder, 2- edge, 3- door, 9- injector; 12- coat..

The diffusion experiments were carried out using a modification of the factory propellant-coating procedure. Semi-finished propellants are supplied in a pre-calculated volume, in a rotary evaporator flask. The substance is dissolved in ethanol and sprayed several times. The mixture was tumbled at a slow rate, sufficient to prevent grains adhering to each other, with the solvent refluxing. This procedure ensured that the concentration of the solution remained effectively constant during the experiment.

3. RESULTS AND DISCUSSION

Propellant is generally designed in different shapes including: 1-hole, 7-hole, 1-hole, strip-shaped, spherical. Each of the reusable particle shapes has a different burning type, including three main types: fixed fire (constant surface area burn), reduced fire (reduced surface area) and increased fire (surface area increased fire) during fire. As for making the particle shape of the propellant which area of fire surface decreases, two following methods are usually done: Method 1, the shape of the propellant particles in the form of 7-holes cylindrical, in this form the surface area of the fire is smaller than the surface area of fire from inside. In Method 2, a centrifugal nucleus was produced with a hole in the middle, and the outside was covered with a coated-deterrent layer.

However, for small propellants grains, it is not possible to coat individual propellant particles separately. The authors make propellant according to both 2 ways. Deterrents agents of flame retardants are substances with a low flammability, low molecular weight and soluble in solvents (ethanol, ethyl ether). The authors used camphor $C_{10}H_{16}O$ (dissolved in alcohol solvent) to adjust the fire rate (particle) of propellant particles. The principle of this method is based on the camphor diffusion from area where has the high concentration, penetrates deeply inside of the particle accelerator where the concentration is lower. The depth of the diffusion layer depends on the mode technology and usually from a few dozen to several hundred micrometers (this method is called taming method of propellant). The concentration of camphor is gradually reduced from the outer layer to the inner layer of the propellant, in other words the energy of the particles increases from the outer layer to the interior, leading to the burning rate (u1) outer layer is lower than inner layer. Figure 3 describes the effect of the homing layer on the firing speed of the propellant [1]:

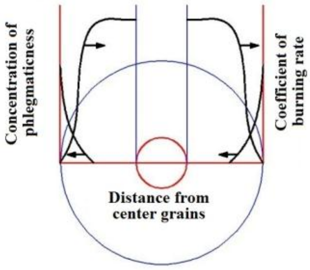

Figure 3. Diagram concentration of phlegmatiness and coefficient burning rate of single based propellant.

Using method by spraying camphor-alcohol on equipment that is used for single-based propellant, after work product was dried until ethanol and diethyl ether of 0.5÷0.8 %, moisture of 1.0÷1.5 % and to define concentration of camphor, coefficient of burning rate, burning time reaching the maximum pressure for comparing to the propellant before absorbing (M0). The following results:

Table 1. Some results for non-phlegmatic (sample- M0) and phlegmatic propellant (M1÷4).

N^0	Parameters	Model and result				
		M0	**M1**	**M2**	**M3**	**M4**
1	Concentration of camphor, %	0	1.26	1.30	1.50	1.55
2	Coefficient of burning rate u_1, mm/(bar.s)	0.0962	0.0787	0.7040	0.0676	0.0638
3	Burning time reaching the maximum pressure, ms	11.0	11.498	12.0	13.0	13.37

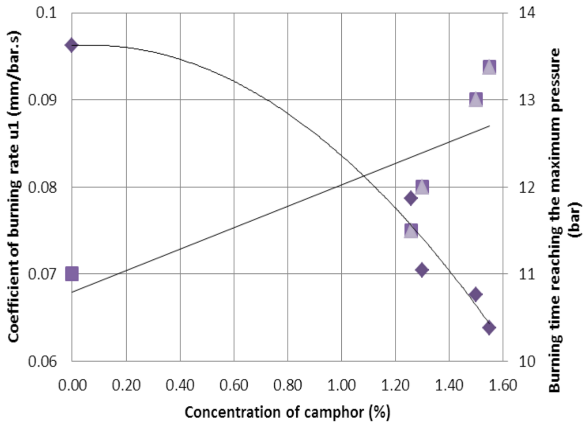

Figure 4. Graphic describing the change main parameters in sample and phlegmatic propellant.

The results compared to the non-phlegmatic propellant sample M0 showed that when the same method of phlegmatization, the change in the content of camphor could change the burning ratio of the powder grains. In particular, with an increase in the content of camphor from 0 to 1.55 %; the combustion coefficient of burning rate of propellant u1 decreased by 33.7 %; thanks to this, the burning time lengthen upto 21.5 % (Figure 4).

4. CONCLUSIONS

Thus, using a phlegmatized solution containing camphor that penetrates into grains, the seven-hole of single-based propellant (alcohol is removed during the drying process to the desired value). We can control the burning rate of the powder in the decreasing direction, while the burning time which are reaching the maximum pressure lengthens. As a result, the projectile moved in the trunk to create an increase in volume, pressure inside balanced on the pressure created by the propellant. Due to this, the pressure graph P(t) or P(l) is maintained at the maximum pressure from the beginning of the projectile to the end of combustion (Figure.1).

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