THE RELATIONSHIP OF THE BURNING RATE OF GUN POWDER GRANULATED WITH THE VARNISH METHOD WITH THE CONTENT OF A PHLEGMATIZER IN IT

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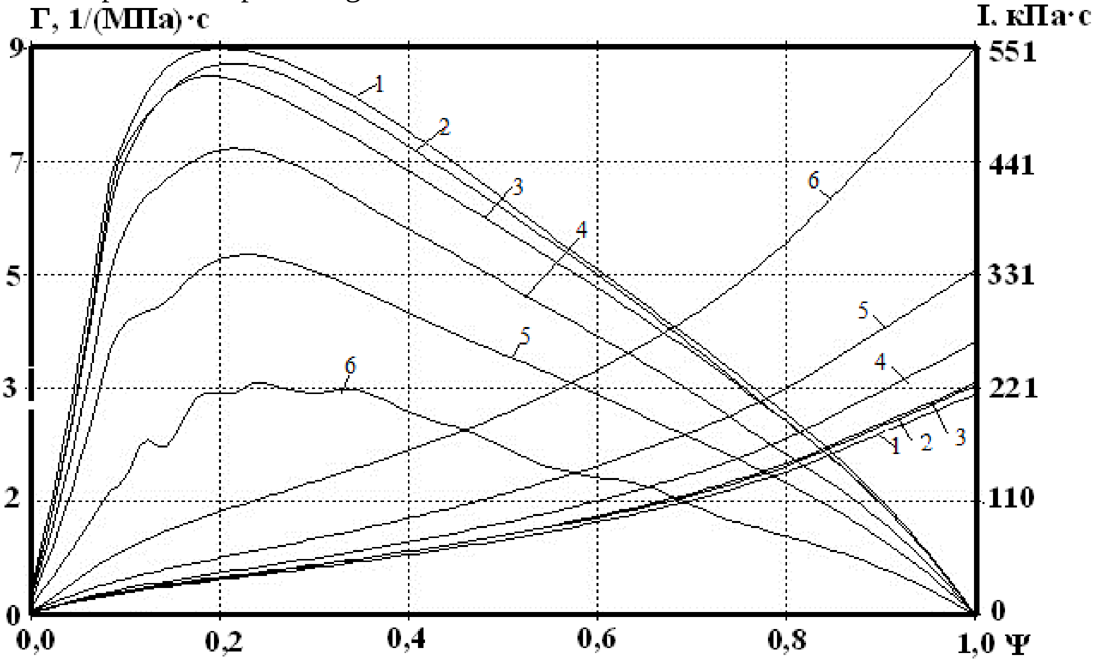
It is known that the effectiveness of barrel weapons largely depends on the progressiveness of the combustion of powder charges [1]. It is usually achieved due to the shape (structure) of powder elements (tube, seven-channel grain, etc.). However, for fine-grained (thin-layer) powders used in small arms and small-caliber artillery, powder elements for technological reasons cannot have a progressive design. Such gun powders also include gun powder granulated with the lacquer method, which is characterized by a completely degressive spherical shape (spherical gun powder) [2]. To ensure progressive combustion, thin-layer powders are subjected to phlegmatization, i.e. saturation of the surface layers of powder elements with substances that reduce the burning rate. This allows you to change the burning rate according to the thickness of the burning layer, and accordingly set the required nature of the gas flow during the shot.

Despite the great value of phlegmatized gunpowder for small arms and small-caliber artillery, relatively few works have been devoted to the study of their combustion process.

In work [1], general ideas about the combustion of phlegmatized gunpowder, based on the analysis of the curves of changes in the intensity of gas formation, are presented. Information on the influence of phlegmatization on the combustion of spherical gunpowder for specific conditions (7.62 mm rifle cartridge, gunpowder of the SEF-42 brand, phlegmatizer - centralite №1) is given in work [3]. The experimental studies presented by the authors showed that the intensity of the pressure increase of powder gases during a shot is determined with the saturation of the phlegmatized zone of the powder elements. In work [4] it is emphasized that the peculiarities of the combustion of phlegmatized gunpowder do not allow the direct use of classical methods of internal ballistics to predict the optimal characteristics of gunpowder. Therefore, to calculate the charge from phlegmatized gunpowder, the authors suggest considering it as a combined charge from two types of gunpowder with different burning rates. At the same time, they accept the assumption of a constant concentration of the phlegmatizer in the phlegmatized zone, which contradicts the physical and chemical laws of the distribution of low molecular weight substances in polymer materials [5]. In contrast to the considered approach, a model was proposed in [6], which takes into account the distribution of the phlegmatizer according to the thickness of the layer of burning spherical powder elements. This model made it possible to relate the main characteristics of gunpowder combustion (intensity of gas formation, pressure pulse and pressure of gunpowder gases) with the change in the burning rate according to the radius of the gunpowder elements, assuming its inverse proportionality with the distribution of the phlegmatizer concentration. This assumption is used in all known works that consider the phlegmatization of gunpowder, but, as a rule, it requires experimental verification.

Due to the fact that the burning rate of phlegmatized gunpowder varies with the radius of the powder granules in accordance with the distribution of the phlegmatizer in them, to calculate the characteristics of the gunpowder combustion, it is necessary to have at your disposal the relationship between the burning rate and the concentration of the phlegmatizer. In this work, such a relationship was established on the basis of manometric tests of gunpowder samples.

To establish the relationship between the speed of burning of gunpowder and the content of the phlegmatizer in it, samples of gunpowder containing a given amount of camphor or dibutyl phthalate were made inside the granules. For this, during granulation, nitrate cellulose varnish was prepared, into which one of the specified substances was introduced, the varnish was thoroughly mixed and granulated by the varnish method. This preparation of samples allows us to assume that the introduced substance is evenly distributed over the volume of the granules. The obtained samples were tested in a manometric installation. As an example, the results of tests of gunpowder with different contents of dibutyl phthalate inside the granules are presented in Figure 1 in the form of curves Γ=f(ψ) and I=f(ψ), where Γ is the intensity of gas formation, I is the pressure pulse of powder gases, ψ is the relative volume container of the burnt part of the powder granule.



curves: 1 – $\bar{a}$=0 мас. %; 2 – 1 %; 3 – 2 %; 4 – 5 %; 5 – 10 %; 6 – 20 %
Figure 1 Experimental dependences Γ=f(ψ) and I=f(ψ) obtained for powder granules containing dibutyl phthalate inside

The analysis of the presented results shows that the introduction of a phlegmatizer into the gun powder, even under the condition of its uniform distribution in the granules, leads to a decrease in the maximum value of the intensity of gas formation with some stretching and a shift to the right of the curves Γ=f(ψ), as well as to an increase in the momentum of the powder gases, i.e. leads to the effect of phlegmatization.

On the basis of manometric tests, the burning rates of powder granules containing different amounts of phlegmatizer were determined, and a graph of the dependence of the ratio of the burning rate coefficients u1/u1n on the volume-mass concentration of the phlegmatizer in the granules was constructed (Figure 2), where *u1, u1n* are coefficients burning rate of gunpowder, respectively, containing a phlegmatizer, and without a phlegmatizer.

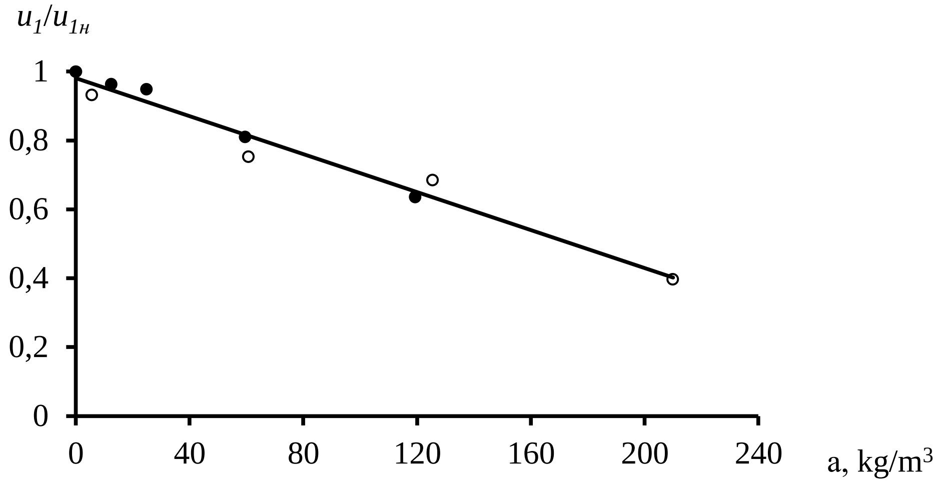


Figure 2 Generalized dependence of the burning rate of powder granules on the concentration of phlegmatizers introduced into the granules

These data show that with an increase in the content of the phlegmatizer in the granules, the burning rate of gunpowder decreases, and the resulting dependence is linear. Such processing of experimental data made it possible to generalize them for such phlegmatizers as camphor and dibutyl phthalate, which have different chemical nature. This follows from the figure, in which the experimental points for both phlegmatizers fit quite well on one straight line, which is described by the equation

$$u_1 = u_{1н}(1 - 0{,}00306a), \qquad (1)$$

where a is the volume and mass concentration of the phlegmatizer in the powder.

This equation makes it possible to calculate its burning rate with a known concentration of the phlegmatizer in the gunpowder.

If we assume that the linear nature of the dependence of the burning rate of gunpowder on the concentration of the phlegmatizer in it is preserved during extrapolation over the entire range of the change in the burning rate coefficient, then there is obviously a value of the concentration of the phlegmatizer in the granules at which u_1=0, i.e., the gunpowder does not burn.

This critical concentration value, as follows from equation (1), is equal to $a_к$=326,9 kg/m^3 (averaged for both phlegmatizers). A test in a manometric bomb of a sample of gunpowder granulated with the lacquer method with a phlegmatizer content above this value of a=459.6 kg/m^3 (mass fraction 40%) showed that such a sample does not ignite under the condition of the standard weight of the igniter (DRP) embedded in the bomb. This experimentally confirms the existence of a critical concentration value of the phlegmatizer.

Conclusions

On the basis of experimental studies, it was established that the relationship between the rate of gunpowder burning and the concentration of the phlegmatizer in it is linear, and the value of the critical concentration of the phlegmatizer in the powder, at which the gunpowder does not burn on its own, was also determined. An empirical equation was obtained that allows you to calculate the burning rate coefficient based on the given concentration of the phlegmatizer in the powder.

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