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Abstract

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ON THE DETONATION OF MIXTURES OF NITROMETHANE WITH ACETONE

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The modern hydrodynamic theory of detonation was first proposed by Ya. B. Zel' dovich (^1). According to this theory, a detonation wave is a shock wave with a smooth front, behind which an exothermic chemical reaction takes place. As a result of a number of works (^2-8) carried out in recent years, it has been established that the shock front of a detonation wave in gases (in detonation in tubes and in spherical detonation (^8)), owing to the instability of the ignition zone (^3), is not plane. The reaction does not take place over the entire front of the detonation wave, but in separate foci—the places of collision of oblique compression discontinuities, which move along the shock front of the detonation wave. In the work of K. I. Shchelkin (^3) it was suggested that the detonation of condensed explosives should have an analogous character. However, until recently there had been no clear experimental confirmation of this suggestion.

In the present work, by means of the method described in (^9), the detonation of nitromethane (NM) and its mixtures with acetone (A) was investigated. The essence of the method consists in photographic recording (on an SFR) of the detonation process at the end face of the charge. Owing to the transparency of the liquids investigated, it is possible to observe the propagation of detonation from the beginning to the end of the charge.

In Figs. 1 and 2 a series of photographs is presented of end-face recording of the process of detonation propagation in NM/A mixtures of various percentage compositions. (It should be noted that the photographs in Fig. 2 were obtained at different magnifications.) From the photographs it is seen that the luminosity of the leading front of detonation is nonuniform. The end-face recording of the detonation propagation process represents a system of intersecting light and dark bands, running at a strictly identical inclination for a given mixture, which determines the velocity of propagation of the inhomogeneities along the front of the detonation wave. This means that the reaction begins and proceeds not over the entire front of the detonation wave simultaneously, but in separate foci; moreover, the light lines in the photographs correspond to places of intense chemical reaction, and the dark ones to places where reaction is absent.

Thus, there exist regions in which the most favorable conditions are created for the reaction to proceed. Naturally, by analogy with gaseous detonation (^8),

Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

such regions will be the places of collision of oblique shock waves in the front of the detonation wave.

With an increase in the percentage content of A in the mixture, the number of inhomogeneities over the diameter of the charge decreases. At a small content of A (Fig. 1a) the inhomogeneities are so small that it is difficult to discern them in the photograph with the naked eye. On this basis one may conclude that such inhomogeneities exist also in pure NM, but they cannot be resolved by the available instruments (⁀9).

At a higher content of A in the mixture, the inhomogeneities become so enlarged that the detonation dies out (see Fig. 1b, where the detonation died out long before

Fig. 1. End-on streak record of the propagation of detonation in a mixture of nitromethane with acetone, taken by volume. Shell material—brass; wall thickness 0.5 mm; charge diameter 34 mm; height 150 mm. Percentage composition of the NM/A mixture: **a**—80:20; **b**—78:22; **c**—75:25

Fig. 2. End-on streak record of the propagation of detonation in a mixture of nitromethane with acetone, taken by volume. Shell material—steel; wall thickness 4 mm; charge diameter 40 mm; height: **a** and **b**—150 mm; **c**—84 mm. Percentage composition of the NM/A mixture: **a**—73:27; **b**—70:30; **c**—65:35

to the end of the charge, and Fig. 2c, where the detonation died out near the end of the charge, as is seen from the partial luminosity of the scattering explosion products, in contrast to Figs. 1a, b and Figs. 2a, b, where the explosion products glow over the entire end face of the charge).

It should be noted that the process of detonation propagation in Figs. 1a, b is steady. In these cases the detonation propagates through a charge about 5 diameters long, and the systems of inhomogeneities (bands) do not change. If the detonation passes through 3.5-4 charge diameters, then subsequently, as established in work (10), it propagates steadily. This means that the observed character of detonation propagation is inherent in such explosive substances.

From the fact that the reaction begins simultaneously not over the entire surface of the detonation front, but in separate foci, it may be concluded that the detonation front in liquid explosives is not plane.

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Note: Figure translations are in progress. See original paper for figures.