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Abstract

Full Text

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Luminescence of the Front of Low-Velocity Detonation in Nitroglycerin

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It is known (1) that in nitroglycerin charges, depending on the method of initiation, two detonation regimes are possible: a velocity $D_1 = 7.65$ km/sec is realized under a powerful initial impulse and corresponds to the maximum release of energy in the wave; a low detonation velocity with a value $D = 2.0$ km/sec arises under weak initiation. Information on its mechanism of propagation and on the energy released in the wave is lacking.

In studying the luminescence of the low-velocity regime, we succeeded in recording a structure of the detonation front that differs fundamentally from that observed in high-velocity regimes.

The detection of details of the luminescence became possible owing to the use of a high-speed camera and highly sensitive M13 film, placed at our disposal by the Scientific-Research Institute of Cinematography and Photography.

The low-velocity regime, 2.0 ± 0.1 km/sec, was realized in cylindrical nitroglycerin charges $d = 10;\ 15;\ 20;\ 40$ mm with the aid of an intermediate charge of soditol 55/45 ($\rho = 1.0$ g/cm^3, $D = 2.3 \pm 0.1$ km/sec) through a thin Plexiglas plate. Figure 1 presents a photograph of a continuous sweep of the luminescence of the detonation front in a Plexiglas casing from the end face (1a, 1b) through the slit of the instrument (the sweep is from left to right). The first bright band is the entry of the detonation wave from the soditol into the nitroglycerin; after 15–20 μsec a flash was recorded, which then weakened, and in the 2.0 km/sec regime (side sweep) a distinct inhomogeneity arose in the luminescence of the front—a "dark" channel consisting of separate waves of reaction weakening with reduced brightness, propagating from the center of the charge toward the casing, as can be judged from the inclination of the lines. Thus, the reaction proceeds most completely in the parts of the charge adjacent to the casing. Frame-by-frame filming of the detonation of a low-velocity charge from the side against the background of a bright screen made it possible to establish that the disturbance traveling along the casing outruns the front at the center of the charge (Fig. 2). The latter leads to a wave shape concave with respect to the direction of propagation, causing the formation of a cumulative jet when the detonation exits at the end face of the charge.

Fig. 1a

Figure 1: Fig. 1a

Fig. 1b and Fig. 2

Figure 2: Fig. 1b and Fig. 2

Experiments in casings with different elastic-acoustic characteristics showed that the low-velocity detonation regime is disrupted if the speed of sound in the casing material is less than 2.0 km/sec (for example, paraffin, cork, lead, foam plastic). This is also confirmed by data available in the literature concerning attenuation of the low detonation velocity in paper, rubber, etc. ([2]). Figure 3a presents a photograph of the luminescence of a charge during the transition of the low-velocity detonation front from a Plexiglas casing into a paraffin one. The "dark" channel expands and occupies the entire cross section of the charge. The detonation velocity falls by approximately 20–30%.

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Fig. 1a

Fig. 1b **Fig. 2**

Fig. 3

Fig. 4

Conversely (Fig. 3b), in thick-walled steel casings there is a sharp acceleration of the reaction process and disappearance of the channel; the glow becomes uniform over the entire cross section of the charge.

The thickness of the casing is also of substantial importance; for a stable regime with a velocity of 2.0 km/sec it must exceed a certain value that depends on the casing material. Thus, in Plexiglas, at a thickness of 0.1 mm, low-velocity detonation cannot propagate, whereas from 2 to 20 mm a stable regime exists.

The glow of the low-velocity detonation front in glass casings differs somewhat from that observed in Plexiglas tubes, although the dark channel at the center of the charge is retained (Fig. 4). Along with dark waves propagating from the center of the charge toward the casing, there are also reflected waves traveling from the casing toward the center.

With very weak initiation, and also in thin casings or in casings made of a material whose speed of sound is less than 2.0 km/sec (for example, cellophane),

Fig. 3

Figure 3: Fig. 3

Fig. 4

Figure 4: Fig. 4

a fairly stable combustion regime is observed at velocities of 800–1000 m/sec ([3]).

Thus, for the stability of a regime with a low detonation velocity, the presence of a compression wave traveling along the casing ahead of the detonation front is essential (the speed of sound in the material is greater than 2.0 km/sec), which leads to a wave profile concave relative to the direction of propagation. The reaction is initiated most intensely in the layers of nitroglycerin adjacent to the casing.

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[1] Yu. B. Khariton, S. B. Ratner, *DAN*, **41**, 293 (1943). [2] R. Kh. Kurbangalina, Dissertation, Institute of Chemical Physics, Academy of Sciences of the USSR, 1947.

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