CRITERIA FOR RESTORING THE EQUATION OF STATE OF EXPLOSIVES FROM SMALL-ANGLE X-RAY SCATTERING DATA IN THE DETONATION CHEMICAL REACTION ZONE

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According to the data of small-angle X-ray scattering (SAXS) of the nanoparticle – explosive system, at the initial stages of the detonation wave propagation, it is possible to restore the equation of state (ES) of the explosive. The criteria for obtaining the Internal Intelligence System from the SAXS data are formulated. The criteria are based on the use of the SAXS contrast between the electron densities of detonation products and nanoparticles in the Guigné approximation to determine the intensity of the SAXS:

$$I(q) = I_e N V^2 (\Delta\rho)^2 \exp\left(-\frac{q^2 R_g^2}{2}\right), \quad (1)$$

where N is the number of nanoparticles, V is the average volume of the nanoparticle, $\Delta\rho = \rho - \rho_0$ – X-ray contrast, which is proportional to the difference in electron density between the particle (ρ) and its immediate environment (ρ_0), R_g – radius of gyration, I_e – Thomson scattering intensity. According to the equation, the exponential factor that depends on q, is determined solely by the size and shape of the particles (through the radius of inertia, R_g), while the scaling caused by the passage of the detonation wave is due to one of three factors: N, V и $\Delta\rho$.

The HMX-aluminum system is quite well studied [1, 2]. It has been shown that the detonation rate in all cases decreases with the addition of nanoaluminum. The law of conservation of mass is written in the form [3]:

$$\delta = \frac{D}{(D-u)k}, \quad (2)$$

$\delta = \rho/\rho_0$, ρ, ρ_0 – the current density and density of the substance under normal conditions, respectively; $k = \rho_0/\rho_{00}$, ρ_{00} – the maximum density of the substance under normal conditions; D – the speed of the detonation wave. In [4], by fitting the method of least squares to the experimental data, the ratio of

$$D = 5.281(14) + 1.306(17) u_s. \quad (3)$$

The solution of the system of equations (2) – (3) makes it possible to calculate D и u_s. Then, using the Hugonio equation,

$$E_\Gamma - E_0 = (p_\Gamma + p_0)\frac{k\delta - 1}{2\rho_0\delta} \quad (4)$$

and the law of conservation of momentum

$$p_\Gamma = p_0 + \rho_0 D u \frac{1}{k} \quad (5)$$

Pressure and energy can be found at the front of the shock wave. Here p is the pressure, E is the specific internal energy.

It remains to link the contrast and compression ratios of HMX and aluminum δ_1 and δ_2 on the front of the shock wave:

$$\rho_2 - \rho_1 = \delta_2\rho_{20} - \delta_1\rho_{10}. \quad (6)$$

To do this, you can use the equations of state of HMX and aluminum, for example, in the form of JWL. Having two caloric equations of state $p_{1\Gamma} = p_{1\Gamma}(\delta_1, E_1)$ and $p_{2\Gamma} = p_{2\Gamma}(\delta_2, E_2)$ for HMX and aluminum respectively, and using the ratio (6) can be calculated for $p_{1\Gamma}$, ρ_2 and ρ_1.

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