ISENTROPES OF DETONATION PRODUCTS FOR HE WITH SMALL CRITICAL DETONATION DIAMETER

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Equations of state (EoS) of detonation products are commonly used for solving multiple gas-dynamics problems. Exponential Jones-Wilkins-Lee (JWL) EoS of detonation products is widely applied and adopted in scientific and engineering calculations:

$$P = A\left(1-\frac{\omega}{R_1V}\right)e^{-R_1V} + B\left(1-\frac{\omega}{R_2V}\right)e^{-R_2V} + \frac{\omega E_0}{V}, \tag{1}$$

where P is the pressure, GPa; A, B, C, R_1, R_2, ω are the constants; E_0 is the volume calorimetric detonation energy, MJ/m^3; and V is the relative volume.

This equation has been implemented in the majority of software packages such as AUTODYN, LS-DYNA, ABAQUS, etc. [2] as a main mathematical description of the work of detonation products up to pressures of 0.1 GPa for solving nonlinear dynamics problems [1]. Coefficients for the JWL EoS of detonation products are usually selected from the experiments on copper cylinder wall expansion while using high explosive (HE) samples 20 mm [3] (T20 setup) or 25.4 mm [4] (Cylinder test) in diameter.

In different systems of explosion automatics and detonation logic thin sections of plastic HEs are used, thus, the JWL EoS of detonation products, derived from the data on expansion of cylinders 20 mm in diameter, is unrepresentative. In this case it is reasonable to perform experiments with HE diameters close to that used in the relevant explosive device.

The paper presents the results of experiments on expansion of cooper cylinders 20 mm and 2 mm in diameter, accelerated by detonation products of plastic PETN- and RDX-based HEs. It also gives the calculated isentropes of detonation products in the form of the JWL EoS. Numerical calculations were performed to validate the derived EoS. The constants of the JWL EoS of detonation products, calculated from the data of the T20 experimental setup, are shown to inadequately describe cylinder wall motion accelerated by a charge 2 mm in diameter. Though the detonation rates for charges 20 mm and 2 mm in diameter were the same, the experimental velocity of cylinder wall expansion, having regard to the scaling factor, is found to be about 140 m/s lower for the charge diameter of 2 mm. The isentropes of detonation products for HE charges of different diameters have significant divergences in numerical modeling of cylinder expansion regardless of similarity in detonation parameters (P_{CJ}, D, E_d), and this has not been yet completely explained. Thus, the necessity of plotting a family of isentropes for charges of different diameters becomes evident.

The results of plotting the family of isentropes for plasticized PETN are shown in Fig. 1.

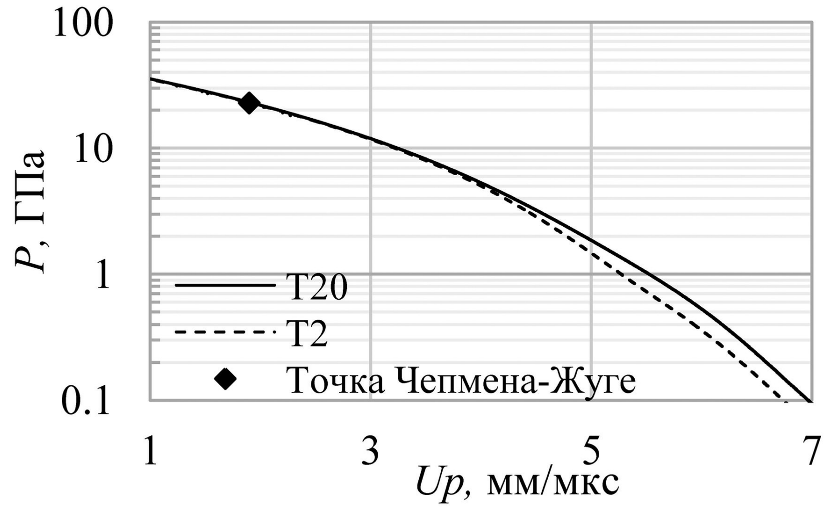

Fig. 1. Family of isentropes of detonation products expansion for plasticized PETN

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