PHYSICAL CHEMISTRY

V. M. ZAITSEV, P. F. POKHIL, and K. K. SHVEDOV

1960

SovietRxiv

Abstract

Full Text

PHYSICAL CHEMISTRY

V. M. ZAITSEV, P. F. POKHIL, and K. K. SHVEDOV

ELECTROMAGNETIC METHOD FOR MEASURING THE VELOCITY OF EXPLOSION PRODUCTS

(Presented by Academician V. N. Kondrat’ev, February 20, 1960)

The direct study of the velocity of explosion products is of great importance both from the standpoint of the development of detonation theory and from the standpoint of the practical use of explosives (E. S.).

In works (1, 2) a method is described for determining the velocity of explosion products which the authors called the “spall” method. The spall method is based on calculating the adiabatic exponent of the explosion products n. Then, using the equations of conservation of mass and momentum, it is possible, from the measured value of the detonation velocity D and the calculated value of the adiabatic exponent n, to determine at the Jouguet point (the point where the Chapman–Jouguet condition is fulfilled, $u + c = D$, u being the velocity of the detonation products and c the speed of sound in the explosion products) the mechanical parameters of the detonation wave (3), such as: $u = \dfrac{D}{n+1}$—the velocity of the explosion products (mass velocity),

Explosives	ρ_0, g/cm^3	D, km/s	u_{em}, km/s	u_{sp}, km/s
Pressed TNT	1.60	7.00	1.81	1.84
» »	1.55	6.77	1.77	1.80
» »	1.47	6.52	1.71	1.73
» »	1.31	6.05	1.58	1.59
» »	1.00	5.10	1.32	1.30
Cast TNT	1.60	7.00	1.81	1.84
Cast TG 50/50	1.68	7.65	2.03	2.07

Table 1

$\rho = \rho_0 \dfrac{n+1}{n}$—the density of the explosion products (ρ_0 being the initial density of the E. S.), $P = \rho_0 uD = \rho_0 \dfrac{D^2}{n+1}$—the pressure in the explosion products.

In the present article the results are described of a direct measurement of the velocity of detonation products by means of an electromagnetic method (^{4}).

This method is based on the appearance of an emf in a conductor moving in a magnetic field. It is assumed that the sensor in the charge, after passage of the detonation front, moves together with the detonation products. The validity of this assumption is confirmed by the fact that the results obtained by this method and by others (^{5}) proved to be close (see Table 1).

Using the relation between the velocity of motion of the sensor u, the length of the sensor l, the magnetic-field strength H, and the magnitude of the induced emf ε, we obtain

$$u = \frac{\varepsilon}{H \cdot l} \cdot 10^8 \ \frac{\text{cm}}{\text{s}},$$

where ε is in volts, H in oersteds, and l in centimeters. The emf induced in the sensor was recorded by means of an OK-17m cathode-ray oscillograph.

The sensor was copper or aluminum foil 0.3-0.5 mm thick, bent into a U-shape. The sensor was made sufficiently wide so that

reduce the influence of the phenomenon of the detonation wave flowing around the sensor. The dimensions of the working section of the sensor are 10×15 mm.

At the suggestion of B. K. Shembel' , we developed a nonstationary method for producing the magnetic field. The magnetic field was produced by passing a direct electric current through the two halves of the coil winding, placed at a distance equal to the radius of the coil. In this case the magnetic-field intensity at the center of the coil can be calculated with a high degree of accuracy from formula (6)

$$H = 0.45 \frac{\omega I}{R}, \tag{6}$$

where ω is the total number of turns of the winding, I is the current flowing in the coil, and R is the radius of the coil.

The current was measured from the voltage drop across a standard resistance of 0.01 Ω connected into the coil supply circuit.

Fig. 1. Schematic representation of the coil for producing the magnetic field and of the charge with the sensor.
1 —cap detonator; 2 —additional detonator; 3 —explosive lens for producing a plane front; 4 —main high-explosive charge; 5 —sensor; 6 —halves of the coil

Fig. 1. Schematic representation of the coil for producing the magnetic field and of the charge with the sensor.

Figure 1: Fig. 1. Schematic representation of the coil for producing the magnetic field and of the charge with the sensor.

Fig. 2. Photograph of an e.m.f. recording induced on a moving sensor

Figure 2: Fig. 2. Photograph of an e.m.f. recording induced on a moving sensor

winding; 7 —wooden support for the charge; B —battery, direct-current source; K —switch for closing the electrical circuit.

Figure 1 shows a schematic representation of the position of the coil for producing the magnetic field and of the charge with the sensor. A typical recording of the e.m.f. from the sensor is shown in Fig. 2.

For calculating the mass velocity of the explosion products, the e.m.f. values were extrapolated to the initial instant of motion of the sensor (point A in Fig. 2), and the e.m.f. value at this point was taken. The average error in determining the mass velocity from a series of 3-5 experiments did not exceed 3%. The experiments were carried out on cast and pressed charges of TNT and of the alloy TG 50/50 (an alloy of equal parts by weight of TNT and hexogen). The results are given in Table 1.

It follows from Table 1 that the electromagnetic method gives somewhat lower results in comparison with the spall method, which is probably explained by the conductivity of the ionized detonation products.

Fig. 2. Photograph of an e.m.f. recording induced on a moving sensor.

A detailed examination of the oscillograms shows that in the initial time interval we have a linear decrease of the mass velocity with time. This indicates that the Poisson adiabat exponent not only does not depend on the initial density (2), but also remains constant over a certain time interval ($3 \div 3.5$ μs) behind the detonation-wave front.

The advantage of this method is that it makes it possible to measure directly the mass velocity not only at the front, but also over a certain time interval behind the detonation-wave front.

Institute of Physical Chemistry
Academy of Sciences of the USSR

Received
20 II 1960

REFERENCES

1. L. V. Al' tshuler, K. K. Krupnikov et al., ZhETF, **34**, no. 4, 874 (1958).

2. J. M. Walsh, R. H. Christian, J. Phys. Rev., **97**, no. 6 (1955).

3. Ya. B. Zel' dovich, A. S. Kompaneets, *Theory of Detonation*, Moscow, 1955.

4. A. A. Brish, M. S. Tarasov, Z. A. Tsukerman, ZhETF, **37**, no. 6(12), 1543 (1959).

5. A. N. Dremin, P. F. Pokhil, DAN, **128**, no. 5 (1959).

6. E. G. Shramkov, *Proceedings of the All-Union Scientific-Research Institute of Metrology*, issue 10/70 (1959).

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

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.