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DETONATION OF CONDENSED EXPLOSIVES WITH LOW-DENSITY CHARGES

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Dover, New Jersey

DETONATION OF CONDENSED EXPLOSIVES WITH LOW-DENSITY CHARGES

Zhurnal Prikladnoy Mekhaniki i Tekhnicheskoy Fiziki (Journal of Applied Mechanics and Technical Physics), Moscow, 1964, No 4, pp 124-126

L. N. Stesik
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The determination of the relationship between the detonation velocity and the initial density of the charge, $D(\rho_0)$, is of practical and theoretical importance. In several papers [1-4], the experimental function $D(\rho_0)$ is used to determine the equation for the state of gases at high pressures. In particular, when the equation for the state is applied in a covolumetric form $p[V - \alpha(V)] = nRT$, the value of the covolume $\alpha(V)$ can be determined with the aid of the function $D(\rho_0)$.

Of definite importance is to measure the velocity of detonation of condensed explosives with a charge having a low density, where the products of the explosion are not governed by the equation of the state of ideal gases, but the elastic component of the pressure is small compared to the total pressure. To this zone correspond pressures resulting from a detonation of explosives whose density is less than 0.8 grams/cm^3. In the majority of cases, however, the lower value of the density at which the detonation velocity of explosives is determined amounts to 0.5-0.6 grams/cm^3. It is a fact that it is difficult to determine the detonation velocity of the majority of explosives at lower densities.

In our work, the relationship between the detonation velocity and the density of explosives was investigated by using nitrocellulose (13.3% N_2) which can provide charges of low density. Because the detonation velocity of nitrocellulose was not measured before, our tests included a wide range of densities of the charge.

cek = sec

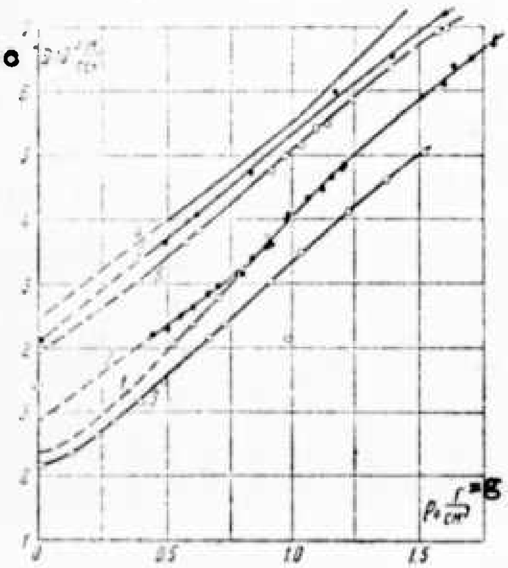

Table 1

ρ_0, (1)	D, (2)	ρ_0, м/сек	D, г/см³
0.13	2400	0.73	4350
0.24	2650	0.85	4750
0.30	2880	0.92	5000
0.40	3160	1.04	5500
0.48	3500	1.23	6150
0.58	3900	1.37	6600
0.67	4150	1.53	7050

Key to Table 1: (1) g/cm³; (2) m/sec.

The charges had 20-30 m in diameter. The shells of the charges were made of cellophane. The detonation velocity was measured by the optical method with the aid of photorecorder. Each value of the density of a charge received three to four measurements. The average error of the measurements was less than 1-2%.

The results of the tests are shown in Table 1 and, graphically, in the figure (curve 3).

The least density of a charge amounted to 0.13 g/cm³. This is fairly close to the densities at which the exploded products are governed by the equation for the state of ideal gases. It was important to find out whether the results of the tests will be in agreement with the calculated detonation velocity when the equation for the state of ideal gases can be applied to the products of the detonation. For this, the detonation velocity of the nitrocellulose was calculated for densities of 0.005 and 0.01 g/cm³. The calculated results are shown in Table 2 and are plotted in the figure. As shown by the figure, the extrapolation of the experimentally determined function is in good agreement with the calculated results.

Table 2

Results of Calculation of Detonation Velocity

ВВ (1)	(2) ρ_0, г/см³	(3) D, м/сек	(3) u, м/сек	(4) p, атм	T, °K
…проклетчатка (5)	0.005	2104	967	101.4	3379
	0.01	2124	971	204.6	3435
…отил (6)	0.01	1996	903	178.9	2710
…рил (7)	0.01	2292	1029	233.7	3704
…кр. к-та (8)	0.01	2116	949	199.2	3386
…ксоген (9)	0.01	2371	1092	256.6	3959
…н (10)	0.01	2194	1024	222.8	3806

Key to Table 2: (1) explosive; (2) g/cm³; (3) m/sec; (4) atm; (5) nitrocellulose; (6) trotyl; (7) tetryl; (8) picric acid; (9) hexogen; (10) "T.E.N."

The detonation velocities were calculated with the aid of a computer by assuming that a thermodynamic balance is fully established in the detonation wave. The composition of the exploded products corresponding to the balance is shown in Table 3. The calculation used a heat capacity of 605.4 Kcal/kg for that of the nitrocellulose (13.3% N_2). Similar calculations were made for several other explosives. In all cases, the density of the substance was taken as equal to 0.01 g/cm³. The results of the calculations are shown in Table 2. Table 2 shows the detonation velocity D, the flow velocity of the products u, the pressure p, and the temperature T at the front of the detonation wave. The figure also shows how the calculated results agree with the extrapolated experimentally obtained functions. The experimental data were taken from [5, 6]. The figure shows a good agreement for trotyl (curve 6) and picric acid (curve 5). For the explosives "T.E.N." (curve 4) and hexogen, the calculated results are much lower than the extrapolated values. The largest deviation is observed for hexogen. This difference between the results forced us to check the experimental data for hexogen with charge-density of 1.0 g/cm^3 and less. The hexogen used in our tests consisted of a mixture of two fractions (50/50): finely dispersed powder with particle sizes of 1-10 microns and the fraction of plant-produced hexogen with particles measuring less than 150 microns. The shell of the charges was made of cellophane. The density of the charges varied from 0.53-1.00 g/cm^3. The detonation path was recorded with the aid of a high-speed photorecorder. The least density was used to determine the relationship between the detonation velocity and the diameter of the charge (see Table 4), which was used for determining the ideal detonation velocity [7].

Table 3

Composition of Products of Detonation (moles/kg)

ВВ (1)	CO_2	CO	H_2O	OH	H	H_2	N_2	C	O_2	O	NO
(2)	5.49	15.60	9.15	0.70	0.50	3.21	4.68	—	0.06	0.06	0.11
	5.54	15.55	9.28	0.59	0.40	3.18	4.69	—	0.04	0.04	0.08
(3)	0.01	26.38	0.02	—	0.09	10.38	6.05	3.31	—	—	—
(4)	1.02	23.34	2.21	0.21	0.94	5.92	8.68	—	—	0.02	0.03
(5)	1.84	24.35	2.38	0.12	0.40	3.90	6.54	—	—	—	0.02
(6)	2.59	10.92	8.20	1.62	1.19	3.90	13.27	—	0.20	0.25	0.47
(7)	6.86	8.96	9.78	2.26	0.56	1.47	5.99	—	1.08	0.43	0.66

Key to Table 3: (1) explosive; (2) nitrocellulose; (3) trotyl; (4) tetryl; (5) picric acid; (6) hexogen; (7) "T.E.N."

The determination of the ideal velocity resulted in a value equal to 4060 m/sec, which differs by only 1.5% of the detonation velocity of a charge having 30 mm in diameter, except in tests with densities of 0.9 and 1.0 g/cm^3 whose charges had a diameter of 20 mm. The results of the tests are shown in Table 3 and in the figure (curve 1), which shows that for densities below 0.8 g/cm^3 there is difference between our data and the data of [5]. Our data are somewhat lower. It is apparently due to the earlier employed shells which were made of glass tubes. At detonation velocities of less than 5000 m/sec, the shock wave in glass overtakes the detonation front which may produce higher results in measuring detonation velocities. For the new data, the extrapolation of the curve $D(\rho_0)$ to zero density for hexogen yields a result which agrees well with the calculation.

Table 4

Detonation Velocity of Hexogen

(1) ρ_0, г/см³	(2) Диаметр заряда, мм	Скорость (3) детонации, м/сек
0.53	10	3620
0.53	20	3900
0.53	30	4000
0.61	30	4390
0.70	30	4780
0.80	30	5240
0.90	20	5750
1.00	20	6040

Key to Table 4: (1) g/cm³; (2) Diameter of charge, mm; (3) Detonation velocity, m/sec.

Submitted 6 Jan 1964

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13. ABSTRACT

Of definite importance is to measure the velocity of detonation of condensed explosives with a charge having a low density, where the products of the explosion are not governed by the equation of the state of ideal gases, but the elastic component of the pressure is small compared to the total pressure. To this zone correspond pressures resulting from a detonation of explosives whose density is less than 0.8 grams/cm^3. In the majority of cases, however, the lower value of the density at which the detonation velocity of explosives is determined amounts to 0.5-0.6 grams/cm^3. It is a fact that it is difficult to determine the detonation velocity of the majority of explosives at lower densities.

In our work, the relationship between the detonation velocity and the density of explosives was investigated by using nitrocellulose (13.3% N_2) which can provide charges of low density. Because the detonation velocity of nitrocellulose was not measured before, our tests included a wide range of densities of the charge.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Initial density of charge Detonation velocity Equation of state Gases at high pressure Low-density explosives Nitrocellulose Ideal gases Trotyl Tetryl Picric acid Hexogen "T.E.N." Exploded products Calculated data vs experimental results						

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