INFLUENCE OF RAYLEIGH–TAYLOR INSTABILITY ON THE RADIATION CHARACTERISTICS OF THE EXPLOSION OF AN EXPLOSIVE IN AIR

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It is shown theoretically in [1] that the interface between explosion products (EP) and the gas behind a shock front is blurred when the EP density is substantially higher than the gas density because of the development of a Rayleigh–Taylor instability. Its influence on the ionized gas parameters is investigated in [2] in experiments with a cylindrical explosion. It is shown that its electrical conductivity can be reduced by two orders of magnitude because of EP mixing with the heated gas behind the shock front. Because of the high optical transparency of air in a shock at low temperatures [3, 4] its mixing with the opaque EP can alter substantially the optical and radiational characteristics of an explosion. In this connection, experimental investigations were performed of the radiational characteristics of an explosion of spherical explosive charges in air with different EP composition.

The tests were conducted in an explosion chamber of around 100 m^3 volume with pressed TEN charges of 1.6 g/cm^3 density and 2.8 and 11 g mass and TG 50 × 50 of 1.45 g/cm^3 density and 11 g mass. The detonator was a small lead azide batch placed at the center of the charge. The TEN EP are gaseous because of the positive oxygen balance of the explosive while they contain solid carbon in the TG 50 × 50 [5].

The development of the luminous domain of the explosion was photographed by a high-speed SFR-2M camera in the time magnifier modification. Photographic recording in a parallel beam of passing light was also performed by a shadow method in the TEN explosion. Pyroelectric sensors with uniform spectral response in the 0.04-1.1 μm range [6] were used to measure the energy radiated by the explosion as a function of the time. The error of such measurements is about 10%. Photographs of the development of explosions of TEN of mass 2.8 g, TEN and TG 50 × 50 of mass 11 g are presented in Figs. 1a-c, respectively. The time between frames in Figs. 1b, c is 16 μsec. The boundaries of the opaque domain occupied by the EP are clearly seen in the shadow photograph (Fig. 1a), while the domain luminous in its own light is inhomogeneous, where the glow lasts longer at the frame edges where the thickness of the gas compressed in the shock is greater. Consequently, the luminous domain on the figure (Fig. 1b) in the time magnifier modification rapidly takes on a ring shape. In contrast to the TEN explosion, the radiation source in the TG 50 × 50 explosion (Fig. 1c) has the shape of a circle.

The difference in the nature of the glow of the TEN and TG 50 × 50 explosions indicates that the latter is closer to a black radiator. Mixing the EP with air behind the shock front being started because of the Rayleigh–Taylor instability is actually the single process that can result in the effect noted. According to [7], the EP temperature is much lower than that of the air in the shock. Consequently, the temperature of the radiating gas diminishes during mixing and is approximately identical for the TEN and TG 50 × 50 explosion, while the high brightness of the explosion of the latter is associated with the lower opti-

TABLE 1

t, msec	E/E_0, %		t, мс	E/E_0, %	
	TEN	TG 50×50		TEN	TG 50×50
0,1	0,008	0,11	2,5	0,065	1,5
0,25	0,011	0,20	5,0	0,13	3,3
0,5	0,016	0,28	10	0,27	7,5
1,0	0,028	0,52	25	0,54	13,6

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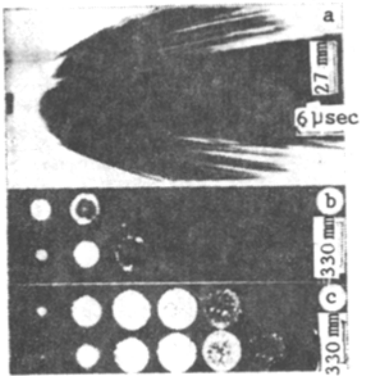

Fig. 1

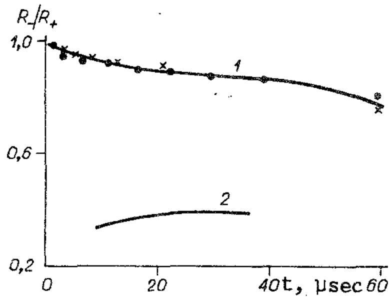

Fig. 2

cal transparency of the gas mixture at the contact boundary because of the presence of carbon in the EP composition.

The time dependence of R_-/R_+ (curve 1) according to computation data [7] (crosses) and [8] (points) that practically are in agreement is presented in Fig. 2 for a TEN explosion (R_- and R_+ are the radii of the contact boundary and the shock front). An analogous dependence 2 is constructed from the results of processing Fig. 1a for the opaque part of the EP. Comparison of curves 1 and 2 indicates significant blurring of the contact boundary, substantially exceeding the linear theory estimate [1].

Averaged results of measuring the scintillation energy E, referred to the energy E_0 of the explosion as a function of time t are represented in the table for the explosion of TEN and TG 50 × 50 charges of 11 g mass. For nearby gasdynamic parameters of the explosion, the radiation energy for the TG 50 × 50 is more than an order higher than that measured for the TEN explosion, which is in agreement with the results of the optical measurements. The main fraction of the energy is radiated in the infrared spectrum range. Analogous results are obtained in tests with charges of different weight from case TG 50 × 50, which are not presented here. At the same time, computations of the scintillation energy from gasdynamic data [7, 8] and air absorption coefficients [3] yield values close to those found for TEN for both explosives.

The tests performed showed that the effects associated with EP mixing with the gas in the shock because of the Rayleigh–Taylor instability permit controlling the radiational characteristics of an explosion. Analogously, the radiational characteristics for the comparatively low re-entry velocities of meteorites into the atmosphere should depend substantially on the mixing conditions of the ablation products with the hot gas heated in the bow shock.

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