Diluent effect of epoxy resin on detonation velocity of PETN*

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Summary

The magnitude of the diluent effect of epoxy resin (EP) on detonation velocity (D) of PETN, which can be expressed by $\Delta D = D_0 - D$, has been evaluated using a coefficient α being formularized as $\Delta D = \alpha D_0$. Here D_0 denotes the detonation velocity of PETN taking the equivalent values as those of PETN/EP in effective density and in charge diameter.

1. Introduction

It has been confirmed experimentally that a detonation velocity of high explosive diluted with an inactive material increases with increasing content of the inactive material[1-4], and then decreases with further increasing the content. The increase has conveniently been explained in terms of an effective density of high explosive, while the decrease in terms of a diluent effect[3)4)]. Strictly speaking, both the increase and decrease should be considered to be associated with effect composing three factors: an effective density, a charge diameter and a content ratio of inactive material to high explosive, so that it is insufficient to explain them as to be attributed to one factor alone.

The present author intends to clarify the dependence of detonation velocity on the three factors, besides, to obtain a procedure of numerical evaluation for the magnitude of the diluent effect on PETN/EP charge.

2. Experimental

PETN (−325 mesh)[5] was used as a high explosive. Two kinds of epoxy resins (EP), EP871 and EP 815[6], were adopted as inactive materials by the following reason. As the density of EP871 is 1.12 g/cm^3 in the cured state, it makes possible to obtain the effective densities ranging from 1.42 to 1.52 g/cm^3. On the other hand, by using EP 815 with the density of 1.17 g/cm^3 in the cured state, the effective densities obtained can be extended up to ranging from 1.50 to 1.61 g/cm^3.

The PETN/EP charge was packed into a polystylene pipe with thin thickness. In the present work an effect of pipe strength on detonation velocity was left out of consideration. Tetryl pellet of 3 gr. was used as a booster to supress an influence owing to initiation strength on detonation velocity. The measurement of detonation velocity was carried out with Hitachi Streak Camera, Model SP-1.

Many charges were prepared by varying the content ratio in the range from 45 to 80 % PETN. Three charges were further provided every content ratio. In every content ratio, the difference between the maximum and minimum values of the loading densities was controlled below 0.01 g/cm^3, and that of the detonation velocities was found to be below 120 m/sec.

3. Results and Consideration

Measurements of detonation velocity were made on the charges with unified diameter of 12 mm. The plots of the detonation velocity D versus the effective density of PETN in PETN/EP charge, ρ_e, which is obtained from the equation $\rho_e = W_1/(1-W_2/d)$ are represented in Fig. 1[3]. Here d is a specific gravity of EP, and W_1 and W_2 are weights of PETN and EP per unit volume of PETN/EP charge respectively. The plots give straight lines with the different slopes as indi-

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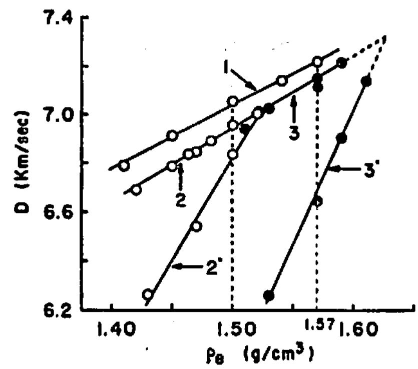

Fig. 1 Plots of D vs. ρ_e for charges with 12 mm in diameter

1) PETN charge
2) PETN/EP871 charge (80/20, 75/25, 70/30, 65/35, 62/38, 60/40)
2′) PETN/EP871 charge (58/42, 55/45, 50/50, 45/55)
3) PETN/EP815 charge (80/20, 75/25, 70/30, 65/35, 62/38, 60/40)
3′) PETN/EP815 charge (58/42, 55/45, 50/50, 45/55)

cated by the arrows 2 (PETN/EP871:80/20∼60/40) and 2′ (PETN/EP871 : 58/42∼45/55) or 3 (PETN/EP 815 : 80/20∼60/40) and 3′ (PETN/EP815 : 58/42∼45/55). The plot of detonation velocity ofPETN, exhibited in the figure, follows a straight line with different slope from those of the PETN/EP charges.

These straight lines enable us to select two charges of PETN/EP characterizing that the content ratio differs each other while the value of effective density is equivalent. The detonation velocity of PETN/EP charge is smaller than that of PETN charge, even if the value of the loading density of PETN is equivalent to the one of the effective density of PETN/EP charge. Therefore, the difference in detonation velocity between the PETN and PETN/EP charges should be interpreted as to be due to the magnitude of the diluent effect ΔD.

On the basis of the preliminary results mentioned above, further investigations for PETN/EP 871 charge with the selected effective density of 1.50 g/cm³ and for PETN/EP815 charge with the one of 1.57 g/cm³ were undertaken. Table 1 gives the content ratios of PETN/EP charge with the two selected effective densities and the detonation velocities of the charges in various diameter R, together with those of PETN charges exhibiting respectively equivalent value in effective density and in charge diameter. The detonation velocity of charge with an infinitely large diameter was calculated from the detonation velocity of the charge with small diameter, on the basis of linear relation between the reciprocal square of detonation velocity and that of charge radius[4].

The diluent effect ΔD can reasonably be expressed as $\Delta D = \alpha D_0$, when not only an effective density but also a charge diameter is preselected and simultaneously the detonation velocity D_0 of

Table 1 Variation of D_0 and D with R at the selected effective density ρ_e

ρ_e (g/cm³)	PETN/EP (wt.%)	$D_0 \cdot D$ (km/sec)	R(mm)					
			8	10	12	15	20	∞
1.50	PETN=100	D_0	6.85	6.98	7.05	7.11	7.16	7.22
	PETN/EP871=60/40	D	6.80	6.93	7.00	7.09	7.14	7.22
		D/D_0	0.992	0.992	0.992	0.997	0.997	1.000
	PETN/EP871=55/45	D	6.64	6.77	6.84	6.93	6.99	7.07
		D/D_0	0.969	0.970	0.970	0.975	0.976	0.979
1.57	PETN=100	D_0	7.04	7.15	7.21	7.27	7.31	7.35
	PETN/EP815=62/38	D	6.95	7.08	7.14	7.20	7.26	7.33
		D/D_0	0.987	0.990	0.990	0.991	0.993	0.997
	PETN/EP815=50/50	D	——	6.51	6.63	6.82	6.92	7.11
		D/D_0	——	0.910	0.920	0.938	0.947	0.967

PETN charge exhibiting the equivalent value to the effective density of PETN/EP charge is adopted as a standard. In practice, it makes possible to evaluate the diluent effect ΔD by the coefficient α obtained from the equation $\alpha=1-(D/D_0)$ using the values of D and D_0 found experimentally. Fig. 2 shows the relationship between the coefficient α obtained in this manner and the charge diameter R, exhibiting that the values of α become smaller with increasing diameter.

It is desirable to take the value of detonation velocity of the charge with infinite diameter as a base of evaluation of the value of α, to rule out any diameter effect. From Fig. 2, it has become apparent that in the case of PETN/EP871=60/40 charge with the infinite diameter at the effective density of 1.50 g/cm^3, the value of α is almost zero, while in the case of PETN/EP871=55/45, it becomes the value of 2.1×10^{-2}. Using the EP 815 charges with the infinite diameter at effective density of 1.59 g/cm^3, the value of α can be evaluated as 0.3×10^{-2} for the charge of PETN/EP 815=62/38 and as 3.3×10^{-2} for the charge, 50/50.

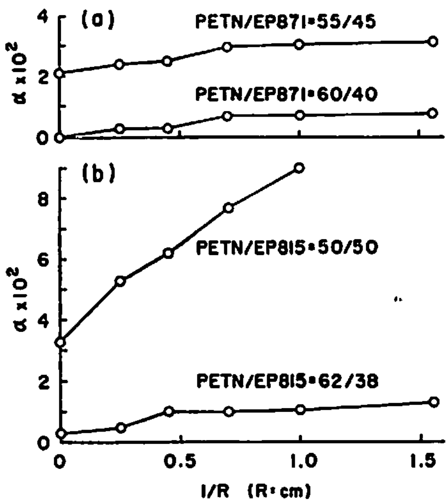

Fig. 2 Plost of α vs. $1/R$

(a) PETN/EP871 at ρ_e=1.50 g/cm^3

(b) PETN/EP815 at ρ_e=1.57 g/cm^3

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PETN の爆速に対するエポキシ樹脂の希釈効果

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PETN の爆速 (D) に対するエポキシ樹脂の希釈効果の大きさ, $\Delta D=D_0-D$, を式 $\Delta D=\alpha D_0$ で定義される α を用いて評価した。ここに D_0 は PETN/EP と同一有効密度および同一薬径における PETN の爆速である。

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