Abstracts of Papers

The following eighteen papers are the first part out of eighty papers, read before the semi-annual meeting of the Institute on June 6 and 7, 1952.

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1. Theory of Detonation Velocity in Gas. (II)

Effect of Inert Gases

Rempei Goto and Nishio Hirai

(Goto Laboratory)

We reported previously that the propagation velocity of detonation in gas or solid explosives could be given by the velocity of transference of energy released from the flame front and reserved in the reactant systems as their kinetic energy. [This Bulletin, 23, 28 (1950).] In the stoichiometric mixture of hydrogen and oxygen ($H_2 + \frac{1}{2}O_2$), the detonation velocity V_0 was given by the relation

$$\frac{1}{2}MV_0^2 = JQ\frac{f_{tH_2O}}{F_{H_2O}} \tag{1}$$

where M is the total mass of reactant system, J the mechanical equivalent of heat, f_{tH_2O} is the translational degrees of freedom of water molecule, and F_{H_2O} the total degrees of freedom of water molecule. It was assumed that for the energy distributed to the reactant molecules (H_2O) the equipartition law holds, but for the excess or inert gas molecules the energy of combustion may be distributed mainly to their translational degrees of freedom. Thus, for the reaction system

$$H_2 + \frac{1}{2}O_2 + xX \longrightarrow H_2O + xX + Q,$$
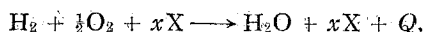
where x is the number of moles of inert or excess gas (X) and Q the heat of combustion, the detonation velocity V was given by the relation

$$V = V_0\left\{\frac{1+x}{(1+0.25x)\ (1+x\frac{Mx}{M_{H_2O}})}\right\}^{\frac{1}{2}} \tag{2}$$

where Mx and M_{H_2O} are the molecular weight of the inert gas and water molecules respectively, and V_0 the detonation velocity in the stoichiometric mixture. Calculated values of detonation velocity given by Eq. (2) showed fairly good agreement with the observed values as shown in the next table.

Table 1. Effect of inert gases on the detonation velocity in $(H_2 + \frac{1}{2}O_2)$ mixture.

X	x mole	V/Vobs.	Vcalc. m/sec.	V obs. m/sec.	Vcalc./Vobs.
O_2	0.5	0.8401	2368	2314	1.02
	1.5	0.7042	1985	1922	1.03
	2.5	0.6289	1772	1700	1.04

N_	0.5	0.8660	2441	2407	1.01
	1.5	0.7385	2081	2055	1.01
	2.5	0.6637	1871	1822	1.03
H₂	1	1.290	3382	3273	1.03
	2	1.279	3605	3527	1.02
	3	1.309	2690	3532	1.05
He	0.75	1.124	3168	3010	1.05
	1.5	1.166	3282	3130	1.05
	2.5	1.176	3315	3160	1.05
A	0.75	0.744	2097	1950	1.08
	1.5	0.648	1823	1800	1.02
	2.5	0.573	1616	1700	0.95
2.82 He 18A $Mx=14.8^*$	2.0	0.870	2451	2390	1.03
1.5 He 1.5A $Mx=22.0^{**}$	1.5	0.801	2238	2330	0.97

$$* \quad Mx = \frac{4 \times 2.28 + 40 \times 1.18}{2.82 + 1.18} = 1.48$$

$$** \quad Mx = \frac{4 \times 1.5 + 40 \times 1.5}{1.5 + 15} = 22.0$$

2. Theory of Limit of Inflammability. (II)

Lower Limit

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According to the theory proposed by Goto [Rev. Phys. Chem. Japan, **21**, 152 (1942)], the correlation between lower limit of inflammability (c_1) and molar heat of combustion (Q) can be expressed by the equation

$$\frac{1}{c_1} = \frac{k}{E} Q + k, \tag{1}$$

where k is a constant and E the heat of activation. The linear relation frund between $\frac{1}{c_1}$ and Q suggests that the activation energy of combustion E is almost constant for most of combustible gases and vapors. By the method of least squares, we have $k/E = 0.090$, $k = 1.56$ and accordingly $E = 17$ (Kcal). Assuming that the heat of combustion are distributed equally among all degrees of freedom of excess molecules in a unit volume per one molecule of combustible and that the flame propagation can occur when the energy distributed to every one of oxygen molecule exceeds the activation energy E, the condition for inflammation was given by the relation

$$c_1(Q+E) + \tfrac{1}{2} fRT = E \tag{2}$$