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.

---

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

$$\tfrac{1}{2}MV_0^2 = JQ\frac{f_{t\,H_2O}}{F_{H_2O}} \qquad (1)$$

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

$$H_2 + \tfrac{1}{2}O_2 + xX \longrightarrow H_2O + xX + Q,$$

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

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

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_2	0.5 1.5 2.5	0.8660 0.7385 0.6637	2441 2081 1871	2407 2055 1822	1.01 1.01 1.03
H_2	1 2 3	1.290 1.279 1.309	3382 3605 2690	3273 3527 3532	1.03 1.02 1.05
He	0.75 1.5 2.5	1.124 1.166 1.176	3168 3282 3315	3010 3130 3160	1.05 1.05 1.05
A	0.75 1.5 2.5	0.744 0.648 0.573	2097 1823 1616	1950 1800 1700	1.08 1.02 0.95
2.82 He 18A M_X=14.8*	2.0	0.870	2451	2390	1.03
1.5 He 1.5A M_X=22.0**	1.5	0.801	2258	2330	0.97

* $M_X = \dfrac{4\times 2.28+40\times 1.18}{2.82+1.18} = 1.48$

** $M_X = \dfrac{4\times 1.5+40\times 1.5}{1.5+15} = 22.0$

---

2. Theory of Limit of Inflammability. (II)

Lower Limit

Rempei GOTO and Nishio HIRAI

(Goto Laboratory)

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

$$\frac{1}{c_1} = \frac{k}{E}Q+k, \qquad (1)$$

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

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