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Short Notes on the Air required for the Combustion of Hydrocarbon and their Products of Combustion.

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パラフイン系統の油は比重の増すに從つて、之が單位重量の燃燒に必要なる空氣の重量減少し、ベンジン系統の油は之に反して增加するが、ナフテン系統のものは少しも變化がないことが容易に數學的に證明せられる。

油の單位重量が燃燒して其結果生ずる燃燒產物中の CO_2, H_2O, 及び N_2 が比重の增すに從つて、次の表の如くに變化することも、同樣容易に數學的に證明せられる。

油の系統	CO^2	H_2O	N_2
パラフイン	增　加	減　少	減　少
ナフテン	一　定	一　定	一　定
ベンジン	減　少	增　加	增　加

The hydrocarbon used in oil engine is sometimes represented by a single member which predominates in quantity as hexane in gasoline, but it is really a mixture at variable proportion of several members of different groups or series. An approximate determination of the amount of air required for the combustion of the fuel and of the constituents of its dropucts of combustion may be done with reference to the representative member and this will be practically sufficient in the design of carburettor and the allied subjects.

But the more thorough knowledge about hydrocarbon fuels will be obtained by knowing how the air for combustion and the products of combustion per unit weight of fuel vary with the specific gravity of the member and this variation is easily found in the following manner.

All hydrocarbons whether saturated or unsaturated may be represented by a general formula $C_nH_{2n+2\alpha}$, where α is positive, negative, or zero as the case may be. Generally speaking the chief constituents of petroleum oils up to, say, gas oil are paraffines and naphthenes. benzenes or aromatics and unsaturated hydrocarbons like olefines being small in quantity.

Considering now saturated hydrocarbons only we have

α=Positive and equal to unity for paraffin series,
=Zero for naphthene series,
=Negative and equal to 3 for benzene series.

The equation of combustion of hydrocarbon becomes now:—

$$C_nH_{2n+2\alpha}+(3n+\alpha)O.=nCO_2+(n+\alpha)H_2O. \qquad \text{.....................(1)}$$

By this equation we know easily that.

1 gm. of a hydrocarbon whose chemical formula is $C_nH_{2n+2\alpha}$ requires

$$\frac{16\times(3n+\alpha)}{14n+2\alpha} \quad \text{gms. of oxygen,}$$

and accordingly

$$4{\cdot}35\times\frac{19\times(3n+\alpha)}{14n+2d}=\frac{34.8(3n+\alpha)}{7n+\alpha} \quad \text{gms. of air for combustion.}$$

Now let W_a=weight of air in gms. required for the combustion of 1 gm. of a hydrocarbon represented by $C_nH_{2n+2\alpha}$, then

$$W_a=\frac{34{\cdot}8(3n+\alpha)}{7n+\alpha}, \qquad \text{..(2)}$$

showing W_a is a function of n or specific gravity.

To find the law of variation of W_a with regard to n we differentiate the former with respect to the latter and get from *Eq.* (2)

$$\frac{dW_a}{dn} = -\frac{139.2\alpha}{(7n+\alpha)^2} \text{...} (3)$$

For paraffin series where α is posittve, the above differential coefficient remains always negative, indicating that the combustion air per unit weight of hydrocarbon diminishes as n increases or in the other words the specific gravity increases.

For naphthene series whose α is zero, the above coefficient vanishes for all values of n and there occurs no variation in the air for combustion.

For benzene series having negative α, the derivative given by *Eq.* (3) Positive, the condition being just opposite to the case for paraffins.

Petroleum oils of Japanese origin consist chiefly of paraffins and naphthenes and therefore we may conclude from the above saying that the amount of air for combustion per unit weight of the fuel should not be increased but decreased when the fuel is changed for one having a higher specific gravity, Again returning to *Eq.* (1). We see that one gm. of $C_nH_{2n+2\alpha}$ produces after complete combustion.

$$W_c = \frac{44n}{14n+2\alpha} = \frac{22n}{7n+\alpha} \quad \text{gms. of } CO_2,$$

$$W_h = \frac{18(n+\alpha)}{14n+2\alpha} = \frac{9(n+\alpha)}{7n+\alpha} \quad \text{gms. of } H_2O,$$

and

$$W_n = 3{\cdot}35 \times \frac{16(3n+\alpha)}{14n+2\alpha} = \frac{26{\cdot}8(3n+\alpha)}{7n+\alpha} \quad \text{gms. of } N_2.$$

To know how W_c, W_h, and W_n vary with n we proceed as before, and obtain the following results :—

$$\frac{dW_c}{dn} = \frac{22\alpha}{(7n+\alpha)^2},$$

$$\frac{dW_h}{dn} = -\frac{54\alpha}{(7n+\alpha)^2},$$

and

$$\frac{dW_n}{dn} = -\frac{107{\cdot}2\alpha}{(7n+\alpha)^3}$$

From the same reasoning as one given for *Eq.* (3), the variation in the constituents of the products of combution per unit weight of hydrocarbon may be tablated as follows :—

Hydrocarbon series.	Products of combustion per unit weight of hydrocarbon.		
	CO_2	H_2O	N_2
Paraffins	Increase	Decrease	Decrease
Naphthenes	No change	No change	No change
Benzenes	Decrease	Increase	Increase

When petroleum oil of Japanese origin used as a fuel is for changed one of a heavier description, CO_2 in the products of combustion per unit weight of the fuel increases while H_2O and N_2 go in the opposite sense.

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