12.9. DETERMINATION OF EXCESS AIR SUPPLIED PER KG OF FUEL

The oxygen content in the fuel remains in combination with hydrogen, and therefore the oxygen carried in the flue gases comes only from the air supplied for the combustion of fuel. Also if there is incomplete combustion of carbon (to CO), then the oxygen necessary to convert the CO to CO_2 should be taken into account in calculating the excess air supplied.

As discussed in article (12.7), one kg of flue gas contains $\frac{28C_1}{100\Sigma X}$ kg of CO and $\frac{32O}{100\Sigma X}$ kg of oxygen. If $\frac{28C_1}{100\Sigma X}$ kg of CO is burned to CO_2, the oxygen required for this

$$= \frac{28C_1}{100\Sigma X} \times \frac{4}{7} = \frac{16C_1}{100\Sigma X}$$

$\therefore$ Excess oxygen available per kg of flue gas formed $= \frac{32O}{100\Sigma X} - \frac{16C_1}{100\Sigma X} = \frac{16}{100\Sigma X}(2O - C_1)$

Excess oxygen supplied per kg of fuel = Excess O_2 per kg of flue gas $\times m_g$

$$= \frac{16}{100\Sigma X}(2O - C_1) \times \frac{C\Sigma X}{12\,(C_1 + C_2)} = \frac{4C}{300}\left(\frac{2O - C_1}{C_1 + C_2}\right)$$

$\therefore$ Excess air supplied per kg of fuel

$$= \frac{4C}{300}\left(\frac{2O - C_1}{C_1 + C_2}\right) \times \frac{100}{23} = \frac{4C}{69}\left(\frac{2O - C_1}{C_1 + C_2}\right) \qquad ...(12.8)$$

12.10. DETERMINATION OF PERCENTAGE OF CARBON IN FUEL BURNING TO CO_2 AND CO FROM THE VOLUMETRIC COMPOSITION OF DRY FLUE GASES

Percentage of carbon burning to CO_2

$$= \frac{\text{Mass of carbon in } CO_2 \text{ per kg of flue gas}}{\text{Mass of carbon in one kg of flue gas}} \times 100$$

$$= \frac{\frac{44C_2}{100\Sigma X} \times \frac{12}{44}}{\frac{44C_2}{100\Sigma X} \times \frac{12}{44} + \frac{28C_1}{100\Sigma X} \times \frac{12}{28}}$$

$$= \frac{C_2}{C_2 + C_1} \times 100 \qquad ...(12.9)$$

where C_1 and C_2 are the percentages of CO and CO_2 in flue gases by volume.

Similarly percentage of carbon burning to CO

$$= \frac{C_1}{C_1 + C_2} \times 100 \qquad ...(12.10)$$

12.11. DETERMINATION OF MINIMUM QUANTITY OF AIR REQUIRED IN CU. M FOR COMPLETE COMBUSTION OF ONE CUBIC METRE OF GASEOUS FUEL WITH A KNOWN VOLUMETRIC ANALYSIS OF THE GASEOUS FUEL

Chemical equations of combustion for Gaseous Fuels.

(a) $2H_2 + O_2 = 2H_2O$

As equal volume of all gases at any given pressure and temperature contains equal number of molecules.

2 Vol. of H_2 combines with 1 Vol. of oxygen and forms 2 Vol. of H_2O

$\therefore$ 1 Vol. of H_2 + $\frac{1}{2}$ Vol. of O_2 = 1 Vol. of H_2O

(b) $2CO + O_2 = 2CO_2$

2 Vol. of CO + 1 Vol. of O_2 = 2 Vol. of CO_2

(c) $CH_4 + 2O_2 = 2H_2O + CO_2$

1 Vol. of CH_4 + 2 Vol. of O_2 = 2 Vol. of H_2O + 1 Vol. of CO_2

(d) $C_2H_4 + 3O_2 = 2H_2O + 2CO_2$

1 Vol. of C_2H_4 + 3 Vol. of O_2 = 2 Vol. of H_2O + 2 Vol. of CO_2

If the percentage analysis of the gaseous fuel is given then the quantity of air required for complete combustion of one cu. m. of the gaseous fuel can be found with the help of the above equations.

The percentage analysis of a gaseous fuel is given as follows :

Hydrogen	$= H_2\%$
Carbon-monoxide	$= CO\%$
Methane	$= CH_4\%$
Ethane	$= C_2H_4\%$
Carbondioxide	$= CO_2\%$ } Incombustible gases
Nitrogen	$= N_2\%$ } Incombustible gases

The quantity of oxygen required in cu. m per cu. m of gas using the above equations is given by

$$\text{Oxygen} = \frac{1}{100}\left[\frac{H_2}{2} + \frac{CO}{2} + 2\,CH_4 + 3\,C_2H_4\right] \text{ cu. m/cu. m of gas.}$$

As the air contains 21% of oxygen by volume, the quantity of air required in m^3 per m^3 of gas for complete combustion is given by

$$\text{Air} = \frac{100}{21} \times \frac{1}{100}\left[\frac{H_2}{2} + \frac{CO}{2} + 2\,CH_4 + 3\,C_2H_4\right]$$

$$= \frac{1}{42}\,[H_2 + CO + 4\,CH_4 + 6\,C_2H_4]\ m^3 \text{ of air}/m^3 \text{ of gas} \qquad \ldots(12.11)$$