weights, the proportional mass is obtained.

12.8. DETERMINATION OF AIR SUPPLIED PER KG OF FUEL WHEN THE VOLUMETRIC ANALYSIS OF DRY FLUE GASES IS KNOWN AND PERCENTAGE OF CARBON BY MASS IN FUEL IS KNOWN

As discussed above, it is known that 1 kg of flue gas

contains $\frac{28C_1}{100\Sigma X}$ kg of CO and $\frac{44C_2}{100\Sigma X}$ kg of CO_2

The amount of carbon in $\frac{28C_1}{100\Sigma X}$ kg of CO $= \frac{28C_1}{100\Sigma X} \cdot \frac{12}{28} = \frac{12C_1}{100\Sigma X}$.

Amount of carbon in $\frac{44C_2}{100\Sigma X}$ kg of CO_2 $= \frac{44C_2}{100\Sigma X} \cdot \frac{12}{44} = \frac{12C_2}{100\Sigma X}$

Therefore, the total mass of carbon in one kg of flue gas $= \frac{12C_1}{100\Sigma X} + \frac{12C_2}{100\Sigma X}$

$$= \frac{12}{100}\left[\frac{C_1 + C_2}{\Sigma X}\right] \text{ kg of carbon per kg of flue gas}$$

Assuming that the percentage of carbon by mass in the fuel is C and the fuel does not contain any nitrogen.

The carbon in the fuel after combustion completely goes into the flue gases. If the mass of gases formed per kg of fuel burned are m_g then we can write down.

Mass of carbon in fuel = Mass of carbon in the flue gas

$$\therefore \quad \frac{C}{100} = \frac{12}{100}\left[\frac{C_1 + C_2}{\Sigma X}\right] \times m_g$$

The mass of gases formed per kg of fuel is

$$\therefore \quad \boxed{m_g = \frac{C.\Sigma X}{12\,(C_1 + C_2)}} \quad ...(12.6)$$

The nitrogen carried with the air is also carried with the flue gases. One kg of air supplied carries $\frac{77}{100}$ kg of nitrogen. Also one kg of flue gas formed contains $\frac{28N}{100\Sigma X}$ kg of nitrogen and, therefore, the air supplied per kg of flue gas formed

$$= \frac{28N}{100\Sigma X} \cdot \frac{100}{77} \text{ kg of air/kg of flue gas}$$

Mass of air supplied per kg of fuel = Mass of air supplied per kg of flue gas × Mass of the flue gases formed per kg of fuel

$$\therefore \quad m_a = \frac{28N}{100\Sigma X} \times \frac{100}{77} \times m_g = \frac{28N}{100\Sigma X} \cdot \frac{100}{77} \times \frac{C\Sigma X}{12(C_1 + C_2)}$$

$$i.e. \quad \boxed{m_a = \frac{1}{33}\left[\frac{CN}{C_1 + C_2}\right]} \quad ...(12.7)$$

If combustion of carbon is complete then $C_1 = 0$ and measurement of CO_2 alone [illegible] sufficient to find the air supplied.

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

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

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

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

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

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

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

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

12.11. DETERMINATION OF MINIMUM QUANTITY OF AIR ...