

Solution to Problem No 12:

Ultimate analysis:

Carbon = 57.5

Hydrogen = 3.7

Oxygen = 5.8

Sulphur = 3.3

Nitrogen = 1.0

Ash = 16.5

87.8

Moisture = 12.0

Total = 99.8 $\approx$ 100%

Combustible part :

Carbon = 57.5

Hydrogen = 3.7 (moisture free)

Oxygen = 5.8 (moisture free)

Sulphur = 3.3

Representative chemical formula:

100 kg of coal (molecular weight).

$$x = \frac{57.5}{12} = 4.792$$

$$y = \frac{3.7}{1} = 3.7$$

$$z = \frac{5.8}{16} = 0.3625$$

$$k = \frac{3.3}{32} = 0.103$$

$$C_xH_yS_zO_k = C_{4.792}H_{3.7}S_{0.103}O_{0.3625}$$

$$\text{Theoretical } O_2 = 4.792 + 3.7/4 + 0.103 - 0.3625/2 = 5.6387 \text{ kmol}$$

$$\text{Theoretical } N_2 = 3.762 \times 5.638 = 21.213 \text{ kmol}$$

$$\text{Theoretical air} = 4.762 \times 5.638 = 26.85 \text{ kmol}$$

$$\text{Let } T_{\text{amb}} = 30^{\circ}\text{C}$$

$$P_{\text{sat}} = 4.246 \text{ kPa}$$

$$P_{\text{H}_2\text{O, air}} = RH \times P_{\text{sat}}$$

$$P_{\text{H}_2\text{O, air}} = [n_{\text{H}_2\text{O}} / (n_{\text{air}} + n_{\text{H}_2\text{O}})] \times P_{\text{atm}}$$

$$.64 \times 4.246 = [n_{\text{H}_2\text{O}} / (n_{\text{air}} + n_{\text{H}_2\text{O}})] \times 101$$

$$n_{\text{H}_2\text{O}} = (4.246 \times .64 \times 26.85) / (101 - 4.246 \times .64) = 0.742$$

$$n \text{C}_{4.792}\text{H}_{3.7}\text{S}_{0.103}\text{O}_{0.3625} + n\mathcal{E} \times 5.638 \text{O}_2 + n\mathcal{E} \times 21.213 \text{N}_2 + n(0.742 \times \mathcal{E} + 0.66) \text{H}_2\text{O}$$

$$= 13\text{CO}_2 + 7\text{O}_2 + 1.0 \text{CO} + 79.0\text{N}_2 + U \times \text{H}_2\text{O} + V \times \text{C} + 0.103 \times \text{SO}_2$$

$$CR = \frac{UC}{UC + A} 100$$

$$20 = \frac{UC}{UC + A} 100$$

$$UC = 20 \times 16.5 / 80 = 4.125 \text{ Kg}$$

$$V = 0.344$$

$$n \text{C}_{4.792}\text{H}_{3.7}\text{S}_{0.103}\text{O}_{0.3625} + n\mathcal{E} \times 5.638 \text{O}_2 + n\mathcal{E} \times 21.213 \text{N}_2 + n(0.742 \times \mathcal{E} + 0.66) \text{H}_2\text{O}$$

$$= 13\text{CO}_2 + 7\text{O}_2 + 1.0 \text{CO} + 79.0\text{N}_2 + U \times \text{H}_2\text{O} + 0.344 \times n \times \text{C} + 0.103 \times n \times \text{SO}_2$$

Balancing N:

$$n\mathcal{E} \times 21.213 \times 2 = 79.0 \times 2$$

$$\Rightarrow n\mathcal{E} = 3.724$$

Balancing C:

$$4.792 \times n = 13 + 1.0 + 0.344 \times n$$

$$\Rightarrow n = 3.147$$

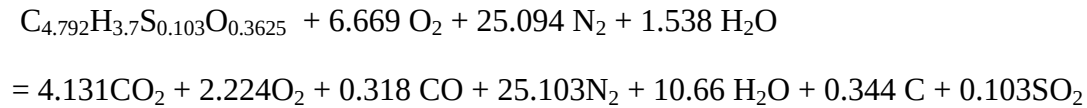
$$\Rightarrow \mathcal{E} = 1.183$$

Balancing H:

$$3.7n + n(0.742 \times \mathcal{E} + 0.66) \times 2 = 2U$$

$$\Rightarrow U = 10.66$$

Combustion equation for 100 kg of fuel:



100 kg of coal requires

$$\mathcal{E} \times 26.85 \times 28.89 = 917.64 \text{ kg of air}$$

$$\text{Actual dry air fuel ratio} = 917.64 / 100 = 9.1764$$

$$\text{Wet air required} = 917.64 + 0.742 \times 1.183 \times 18 = 933.44$$

$$\text{Actual wet air fuel ratio} = 933.44 / 100 = 9.3344$$

100 kg of coal generates

$$4.131 \times 44 = 181.764 \text{ kg of } CO_2$$

$$2.224 \times 32 = 71.168 \text{ kg of } O_2$$

$$0.318 \times 28 = 8.904 \text{ kg of } CO$$

$$10.66 \times 18 = 191.88 \text{ kg of } H_2O$$

$$0.344 \times 12 = 4.128 \text{ kg of } C$$

$$0.103 \times 64 = 6.592 \text{ kg of } SO_2$$

Use the loss equations to calculate the efficiency