

MCG2131 Midterm 12 February 2009

1. (a) Volume fraction = mol fraction, convert to mass:

$$\text{Mean molecular mass } M = 13.4 \text{ kg/kmol}, Y_{\text{CH}_4} = 0.418, Y_{\text{H}_2} = 0.060, Y_{\text{N}_2} = 0.522.$$

(b) use gas law for whole mixture, with $R = \mathcal{R}/M = 0.6204$, get $m = 1.10 \text{ kg}$.

2. (a) Psych. chart shows line moving horizontally left to dew point, then down saturation line to state 2. Reheat is line extending horizontally right from 2 to final state.

(b) $p_v = \phi P_{\text{SAT}} @ 40^\circ\text{C} = 5.169 \text{ kPa}$, then $\omega = 0.0339$.

$$\text{With } h_g = 2574.3, T_{\text{REF}} = -20^\circ\text{C}, h_A = 147.5 \text{ kJ/kg}.$$

$$T_{\text{DP}} = T_{\text{SAT}} @ p_v = 33.3^\circ\text{C} \text{ by interpolation in the steam table.}$$

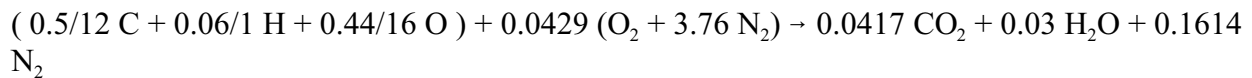
(c) Use perfect gas law with $p_a = P - p_v$ and R_a , get mass flow rate = 1.759 kg/s dry air.

(d) Temperature after cooling found by tracing constant ω line from final state back to saturation line, which gives $T_2 = 14^\circ\text{C}$. From chart read $\omega_2 = 0.0098 \text{ kg/kg dry}$, $h_{A2} = 58.5 \text{ kJ/kg dry}$.

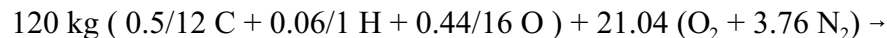
Water balance gives water removal rate as 0.0424 kg/s.

Energy balance: assume enthalpy of liquid leaving = $h_f @ T_2 = 58.8 \text{ kJ/kg}$, then $Q = -154 \text{ kW}$.

3. (a) Stoichiometric combustion: for 1 kg wood



(b) Actual combustion: assume 100 kmol dry products (i.e. $\text{CO}_2 + \text{O}_2 + \text{N}_2$) = 100. Equation balances to



$$\text{Actual O}_2 \text{ for 1 kg fuel} = 21.04/120 = 0.1753$$

$$\text{XS air} = 0.1753/0.0429 - 1 = \mathbf{309\%}.$$