ME 5101 Spring 2007 Quiz 2 Solutions

writing equation with 25% excess air

$$6.25 C + 2.5 H_2 + 0.156 S + 0.078 O_2 + 0.089 N_2 + 0.278 H_2O + (1.25 * 7.58)(O_2 + 3.76 N_2)$$

(6) $$\longrightarrow 6.25 CO_2 + (2.5 + 0.278) H_2O + 0.156 SO_2 + (1.25 * 7.58 \times 3.76 + 0.089) N_2 + 0.25 \times 7.58 O_2$$

↑ from excess

Composition $X = \frac{n}{n_{total}}$

(12)

Component	n_{wet}	X_{wet}	n_{dry}	X_{dry}
CO_2	6.25	0.134	6.25	0.142
H_2O	2.78	0.059	0	—
SO_2	0.156	333 ppm	0.156	354 ppm
N_2	35.7	0.763	35.7	0.811
O_2	1.90	0.040	1.90	0.043
total	46.8		44.0	

(2) $P_{H_2O} = P_a \times X_{H_2O} = 101 * 0.059 = 6 \text{ kPa}$

(2) Check steam tables $T_{sat} = T_{dew} = 36\ °C$

(1) Convert mass to moles and write balanced equation for chemically correct complete combustion.

$$\frac{75}{12} C + \frac{5}{2} H_2 + \frac{5}{32} S + \frac{2.5}{32} O_2 + \frac{2.5}{28} N_2 + \frac{5}{18} H_2O +$$
$$X (O_2 + 3.76 N_2) \rightarrow$$

(6) $6.25 C + 2.5 H_2 + 0.156 S + 0.078 O_2 + 0.089 N_2 + 0.278 H_2O +$
$X (O_2 + 3.76 N_2) \rightarrow 6.25 CO_2 + (2.5 + 0.278) H_2O$
$+ 0.156 SO_2 + (X*3.76 + 0.089) N_2$

O_2 balance

(4) $0.078 + X = 6.25 + \frac{2.5}{2} + 0.156$

to burn C H_2 S

Note the 0.278 H_2O appears on both sides and doesn't change balance

$X = 7.58$ Note we have assumed 100 kg of fuel

(4) $AF_c = \frac{m_a}{m_f} = \frac{7.58 (32 + 3.76 * 28)}{100} = \underline{10.4}$

with 25% excess air

(4) $AF = 1.25\ AF_c = 13.0$

(2) The relative amounts of heat transfer in the furnace, where most boiling

(5) takes place, and the superheating region changes with the load -

(5)+(5) Attemperation
Gas recirculation
Separately fired superheater
Excess air
Gas bypass
Moveable burners

(3) For each stage

$$\eta_s = \frac{\Delta h}{\Delta h_i} = \frac{h_1 - h_2}{h_1 - h_{2i}} \doteq 0.8$$

4×(3) The same for all stages $\eta_s = 0.8$

(5) $$\eta_{overall} = \frac{\Delta h}{\Delta h_i} = \frac{h_1 - h_5}{h_1 - h_{5ii}} = 0.829$$

For equal stage efficiencies

(5) $$R = \frac{\eta}{\eta_{stage}} = 1.036$$

(36) $\dot{Q} - \dot{W} + \Sigma \dot{m}_e (h_e + ke_e + pe_e) = 0$

from steady state steady flow energy balance

(10) $\dot{W} = \dot{m}\left(h_1 + \frac{V_1^2}{2} - \left(h_5 + \frac{V_5^2}{2}\right)\right)$ (4)

$250 \times 10^3 \text{ kW} = \dot{m}\left(3297.1 - 2761 - \frac{50^2}{2 \times 1000}\right)$

to convert from J to kJ

(6) $\dot{m} = 467 \text{ kg/s}$

$\dot{m} = \rho V A = \frac{VA}{v} = \frac{50\,A}{0.193 \text{ m}^3/\text{kg}}$

(7) $A = \frac{0.193 \frac{\text{m}^3}{\text{kg}} \times 467 \text{ kg/s}}{50 \text{ m/s}} = 1.8 \text{ m}^2$