2.615

Solution to H.W. #2

3.1) $C_8H_{18} + 12.5(O_2 + 3.773N_2) \rightarrow 8CO_2 + 9H_2O + 12.5 \times 3.773 N_2$

114 gm $\quad 12.5 \times 4.773 \times 28.96$ gm $= 1727.83$ gm

typical cruise power

Air flow rate: $2 \times \frac{1727.83}{114} = 30.31$ g/s ; Power out $= 2\times10^{-3} \times 44\times10^{6} \times 0.3 = 26.4$ kw

Assume 4 stroke engine, 1 firing cycle per cylinder per two Revolutions, 4 cylinders

$m_f = \left[\frac{2}{4}\ \frac{1}{\frac{1500}{2}\times\frac{1}{60}}\right] = 4\times10^{-2}$ g (A very small amount!)

$m_a = 4\times10^{-2} \times \left(\frac{30.31}{2}\right) = 0.61$ g

$\eta_v = \frac{m_a}{\rho_{ao} V_D}$; $\rho_{ao} = 1.18\times10^{-3}$ g/cc @ 25°C $\Rightarrow \eta_v = \frac{0.61}{1.18\times10^{-3} \times \frac{2500}{4}} = 0.86$

3.3) Propane fueled engine: $\phi(C_3H_8) + 5(O_2 + 3.773N_2) \rightarrow 3\phi CO_2 + 4\phi H_2O + (5 - 3\phi - 2\phi)O_2 + 5\times3.773 N_2$

Note that there is no CO and H2; so must not be fuel rich.

$\frac{N_{CO_2}}{N_{O_2}} = \frac{10.8}{4.5} = \frac{3\phi}{5(1-\phi)} \Rightarrow \phi = 0.80$

3.13) Fuel Lean: no CO or H_2 $\quad \phi C_8H_{18} + 12.5(O_2 + 3.773N_2) \rightarrow 9\phi H_2O + 8\phi CO_2 + 12.5(1-\phi)O_2 + 12.5\times3.773 N_2$

Fuel Rich: $CO : H_2 = 3:1$; let $N_{H_2} = a$, then

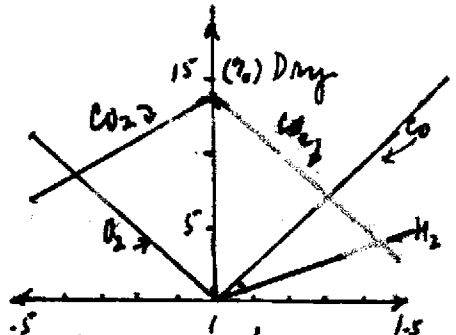
$\phi C_8H_{18} + 12.5(O_2 + 3.773N_2) \rightarrow (9\phi - a)H_2O + (8\phi - 3a)CO_2 + 3a\,CO + a\,H_2 + (12.5\times3.773)N_2$

oxygen balance $\rightarrow a = N_{H_2}$ such that $(9\phi - a) + 2\times(8\phi - 3a) + 3a = 25$

Thus $a = -\frac{25}{4}(1-\phi)$

Moles per ϕ moles of fuel

ϕ	0.5	0.7	1	1.08	1.3	1.5
N_{H_2}	0	0	0	0.50	1.88	3.13
N_{CO}	0	0	0	1.50	5.63	9.38
N_{CO_2}	4	5.6	8	7.14	4.775	2.625
N_{O_2}	6.75	3.75	0	0	0	0
N_{N_2}	←			47.16	→	
dry N_{total}	57.51	56.951	55.16	56.30	59.44	62.29
dry mole fraction χ_{H_2} (%)	0	0	0	0.89	3.15	5.02
dry mole fraction χ_{CO} (%)	0	0	0	2.66	9.46	15.05
dry mole fraction χ_{CO_2} (%)	6.97	9.91	14.5	12.68	8.03	4.21
dry mole fraction χ_{O_2} (%)	10.9	6.64	0	0	0	0



14:1 air Fuel $\Rightarrow \phi = \frac{1/14}{1/(1727.83/114)} = 1.08$

$N_{H_2} = .5$, $N_{CO} = 1.5$, $N_{CO_2} = 7.14$, $N_{N_2} = 47.16$

$N_{H_2O} = (9\phi - a) = 9.22$; $N_{total} = 65.52$

Wet $\chi_{H_2} = 0.76\%$; $\chi_{CO} = 2.3\%$; $\chi_{CO_2} = 10.9\%$

$\chi_{N_2} = 72\%$ $\quad \chi_{H_2O} = 14.1\%$

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