

A 4-cylinder laboratory test engine is supplied with isooctane fuel (C<sub>8</sub>H<sub>18</sub>) at a rate of 1.5 x 10<sup>-3</sup> kg/sec. The fuel air equivalence ratio, phi, is 0.8.

a) The mixture is lean. This means the FA is less than the stoichiometric FA. So the mixture is lean

$$\text{if } \phi < 1.$$

b) Calculate the air flow rate in kg/sec.

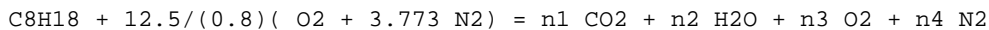
$$\phi = 0.8$$

$$\text{FA} = \frac{\text{MolarMass}[\text{'C8H18'}]}{\frac{12.5}{\phi} \cdot [\text{MolarMass}(\text{'O2'}) + 3.773 \cdot \text{MolarMass}(\text{'N2'})]}$$

$$\text{fuelflow} = 0.0015 \text{ [kg/sec]}$$

$$\text{airflow} = \frac{\text{fuelflow}}{\text{FA}} \text{ [kg/sec]}$$

c) Write and balance the chemical equation describing the combustion process.



$$8 = n_1$$

$$18 = 2 \cdot n_2$$

$$\frac{12.5}{\phi} \cdot 2 = 2 \cdot n_1 + n_2 + 2 \cdot n_3$$

$$\frac{12.5}{\phi} \cdot 2 \cdot 3.773 = 2 \cdot n_4$$

d) Calculate the mole fractions of each of the gases making up the exhaust.

$$n_T = n_1 + n_2 + n_3 + n_4$$

$$y_{\text{CO}_2} = \frac{n_1}{n_T}$$

$$y_{\text{H}_2\text{O}} = \frac{n_2}{n_T}$$

$$y_{\text{O}_2} = \frac{n_3}{n_T}$$

$$y_{\text{N}_2} = \frac{n_4}{n_T}$$

2. This is a continuation of the previous problem. The heating value of the fuel is 42000 kJ/kg. The mechanical efficiency is 0.83, the fuel conversion efficiency (based on brake work/power) is 0.34, and the combustion efficiency is 0.93. We estimate that 35% of the energy entering the engine in the fuel is transferred to the cooling system. Calculate in kW

a) the brake power

$$\eta_f = 0.34$$

$$\eta_m = 0.83$$

$$\eta_c = 0.93$$

$$Q_{HV} = 42000 \text{ [kJ/kg]}$$

$$\text{Power}_{in} = Q_{HV} \cdot \text{fuelflow} \text{ [kW]}$$

$$P_b = \eta_f \cdot \text{Power}_{in} \text{ [kW]}$$

b) the friction power

$$\eta_m = \frac{P_b}{P_b + P_f}$$

c) the indicated power

$$P_i = P_b + P_f$$

d) the heat transfer

$$Q_{dot} = 0.35 \cdot \text{Power}_{in} \text{ [kW]}$$

e) the total power in the exhaust gas

$$P_{exh} = \text{Power}_{in} - Q_{dot} - P_b - P_f$$

f) the rate at which chemical energy leaves the engine in the exhaust gas

$$P_{exhchem} = [1 - \eta_c] \cdot \text{Power}_{in}$$

Unit Settings: [kJ]/[K]/[kPa]/[kmol]/[radians]

$$\text{airflow} = 0.02825 \text{ [kg/sec]}$$

$$\text{FA} = 0.05309$$

$$n_3 = 3.125$$

$$\text{Power}_{in} = 63 \text{ [kW]}$$

$$P_f = 4.387 \text{ [kW]}$$

$$y_{CO_2} = 0.1012$$

$$\eta_c = 0.93$$

$$\text{fuelflow} = 0.0015 \text{ [kg/sec]}$$

$$n_4 = 58.95$$

$$P_b = 21.42 \text{ [kW]}$$

$$P_i = 25.81 \text{ [kW]}$$

$$y_{H_2O} = 0.1138$$

$$\eta_f = 0.34$$

$$n_1 = 8$$

$$nT = 79.08$$

$$P_{exh} = 15.14 \text{ [kW]}$$

$$Q_{dot} = 22.05 \text{ [kW]}$$

$$y_{N_2} = 0.7455$$

$$\eta_m = 0.83$$

$$n_2 = 9$$

$$\phi = 0.8$$

$$P_{exhchem} = 4.41 \text{ [kW]}$$

$$Q_{HV} = 42000 \text{ [kJ/kg]}$$

$$y_{O_2} = 0.03952$$