JQ.2.33.Setup

September 22, 2014

(2.33) A gaseous mixture of 2% (by volume) acetone and 4% ethanol in air is at 25^oC and a pressure of 1 atm.

Data

Acetone (C_3H_6O) has $\Delta h_c = 1786kJ/(gmol)$

Ethanol (C_2H_5OH) has $\Delta h_c = 1232kJ/(gmol)$

Atomic weights are given. Assume that the mass specific heat at constant pressure for each species is $c_{p,i} = 1kJ/(kgK)$.

(a)For a constant pressure reaction, calculate the partial pressure of the oxygen in the product mixture.

(b) Determine the adiabatic flame temperature of this mixture.

(c) If this mixture were initially at 400^oC, what will the resultant adiabatic flame temperature be?

Setup.

(a) The hard way to solve this problem is to try to balance the elements for the combined mixture. By this I mean:

$$2C_3H_6O + 4C_2H_5OH + 96(.21O_2 + 0.79N_2) \rightarrow bCO_2 + dH_2O + eO_2 + fN_2$$

It is easier to do each fuel seperately in a stoichiometric mixture:

$$C_3H_6O + a(.21O_2 + 0.79N_2) \rightarrow bCO_2 + dH_2O + fN_2$$

and

$$C_2H_5OH + A(.21O_2 + 0.79N_2) \rightarrow BCO_2 + DH_2O + FN_2$$

Once you know the stoichiometric reactions, add them together my multiplying by the respective mole fraction (use Amagat's law). Check if there is excess air, excess fuel, or balanced.

(b) We are generalizing the adiabatic flame temperature model to include multiple fuels.Recall that the flame temperature using a mass basis formulation is found from.

$$0 = \sum_i m_{F,i}\Delta h_{c,i} + \sum_i m_i c_{p,i}(T_R - 25) - \sum_j m_j c_{p,j}(T_P - 25)$$

This mass form is particularly useful for a case in which the reactants are already at 25^oC since the sum on the reactant enthalpies is then zero. Next we can define a mass averaged specific heat capacity as:

$$m_T\bar{c} = \sum m_i c_i$$

$$0 = m_{F,1}\Delta h_{c,1} + m_{F,2}\Delta h_{c,2} - m_T\bar{c}(T_P - 25)$$

$$T_P = 25 + \frac{m_{F,1}}{m_T}\frac{\Delta h_{c,1}}{\bar{c}} + \frac{m_{F,2}}{m_T}\frac{\Delta h_{c,2}}{\bar{c}} = 25 + Y_{F,1}\frac{\Delta h_{c,1}}{\bar{c}} + Y_{F,2}\frac{\Delta h_{c,2}}{\bar{c}}$$

(c) Use the same approach as in part (b).

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In []:
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