

JQ.2.33.Setup

September 23, 2014

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

Data

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

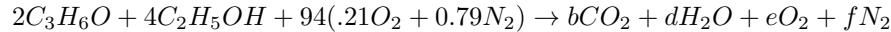
Ethanol (C_2H_5OH) has $\Delta h_c = 1232 kJ/(gmol)$

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

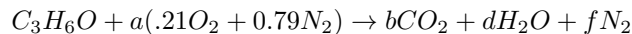
- (a) For a constant pressure reaction, calculate the partial pressure of the oxygen in the product mixture.
- (b) Determine the adiabatic flame temperature of this mixture.
- (c) If this mixture were initially at $400^\circ C$, what will the resultant adiabatic flame temperature be?

Setup.

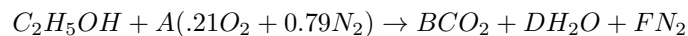
- (a) The hard way to solve this problem is to try to balance the elements for the combined mixture. By this I mean:



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



and



Once you know the stoichiometric reactions, add them together by 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 $25^\circ C$ 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).

In □: