CHG1125 CHEMICAL ENGINEERING FUNDAMENTALS
EXTRA PROBLEMS 8

Monday, March 13th, 2017

1. With the goal of producing nitrous oxide (NO) economically, NH_3 gas is burned with a 20% excess of pure oxygen.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

The conversion of ammonia is 70%. At the exit of the reactor, the gas mixture passes through a separation unit. The unconsumed ammonia is separated and recycled to the reactor entrance.

   a) Calculate the ratio of the number of moles of NO produced per mol of NH_3 in the feed to the reactor (and not the process feed).
   b) Calculate the number of moles of NH_3 recycled per each mole of NO produced.

2. (Textbook 4.49) Methane and oxygen react in the presence of a catalyst to form formaldehyde. In a parallel reaction, methane is oxidized to carbon dioxide and water:

$$CH_4 + O_2 \rightarrow HCHO + H_2O$$
$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

The feed to the reactor contains equimolar amounts of methane and oxygen.

   a) Draw and label a flowchart. Determine how many process variable values must be specified for the remaining variable values to be calculated.
   b) The fractional conversion of methane is 0.90 and the fractional yield of formaldehyde is 0.855. Calculate the molar composition of the reactor output stream and the selectivity of formaldehyde production relative to carbon dioxide production.

3. (Textbook 4.69) A mixture of 75 mole% propane and 25 mole% hydrogen is burned with 25% excess air. Fractional conversions of 90% of the propane and 85% of the hydrogen are achieved; of the propane that reacts, 95% reacts to form CO_2 and the balance reacts to form CO. The hot combustion product gas passes through a boiler in which heat transferred from the gas converts boiler feedwater into steam.

   a) Calculate the concentration of CO (ppm) in the stack gas.
   b) The CO in the stack gas is a pollutant. Its concentration can be decreased by increasing the percent excess air fed to the furnace. Think of at least two costs of doing so.