MAE 112 Fall 2024
Homework Assignment #2

Due: midnight, Sunday, October 20, 2024
Follow submission instructions from TAs Andrew Nichols and Wes Hellwig

1. Calculate theoretical (ideal) flame temperature for methane in stoichiometric ratio with enriched air (50% O_2, 50% N_2 by volume). Pressure is constant at 15 atm and the initial temperature is 298 K.

2. H_2O exists as the major product of combustion for hydrogen and oxygen originally in stoichiometric proportions with no other gas present. Find the fraction of products dissociated to H_2 and O_2 in each of the following conditions for the products:
   (a) 1850 º R and one atmosphere;
   (b) 1850 º R and 10 atmospheres;
   (c) 3100 º R and 10 atmospheres; and
   (d) 1850 º R and one atmosphere but now with hydrogen and air originally.

3. (a) Calculate AF at stoichiometric condition (AF_{st}) for ethyl alcohol C_2H_5OH (aka ethanol) initially at 550 º R burning in air at 20 atmospheres of pressure. AF is the ratio of mass flow of air to mass flow of fuel. Also, calculate FA = 1/ AF for the same condition.
   (b) Calculate AF and $\Phi = AF_{st} / AF = FA/ FA_{st}$ for ethyl alcohol and 50% excess air at the same conditions.

4. (a) Establish the equations which can be employed for the calculation of the equilibrium composition and the flame temperature when one mole of propane C_3H_8 burns adiabatically at a constant pressure of ten atmospheres. The mixture is lean with 75% excess air. Both air and fuel enter at a temperature of 800°R. Consider the products to be CO_2, CO, H_2O, H_2, O_2, and N_2 only. Write all the required equations with known quantities and parameters substituted into the equation. Identify the unknowns. Propane is gaseous at room temperature. Explain what would be different in the analysis if propane entered at a lower temperature in liquid form.
   (b) Use the computer software to calculate the final flame temperature and concentrations of the products with the gaseous propane fuel.
   (c) For the adiabatic situation with gaseous fuel described in Part a, establish the equations to solve for the theoretical (ideal) temperature and composition. What are the products in this case? Again, write the necessary equations, identify the known quantities, and identify the unknowns. Solve the equations for the final temperature and composition. Which of the two temperatures from 2b and 2c is larger? Why?

5. Do a preliminary design on a rocket combustor. A peak temperature of 4500 ºR is desired and the average molecular weight of the hot products should be no greater than 27. Choose an appropriate fuel that will burn with oxygen (O_2). Candidates are ethanol (C_2H_5OH), hydrogen (H_2), and methane (CH_4). Design to have the theoretical (ideal) flame temperature (without dissociation) at 4500 ºR. Determine the proper mixture ratio of fuel to oxygen for that case. Then, calculate the equilibrium temperature which will be a little lower. Estimate the mass

fractions of the products at equilibrium. Determine the average molecular weight of the equilibrium products.

END.