ME 306 : 2023 : Fuels and Combustion

1. Determine the HHV and LHV (on molar as well as mass basis) at 298 K for gaseous n-decane ($C_{10}H_{22}$, Mol. Wt. 142.284). Data: $h^o_{f,C_{10}H_{22}}$ = -249,659 $\frac{kJ}{kmol}$, $h^o_{f,H_2O(l)}$ = -285,857 $\frac{kJ}{kmol}$, h^o_{f,CO_2} = -393,546 $\frac{kJ}{kmol}$.

2. Heptane (C_7H_{16}) is burnt with 50% excess air. Determine (a) stoichiometric air-fuel ratio (b) actual air-fuel ratio (c)oxygen present in products by volume and (d) calorific value

3. A sample of coal has the following composition by weight: C= 78%, H2 = 5%, rest ash. Determine (a) the stoichiometric air-fuel ratio (b) actual air-fuel ratio if it is burnt in 30 % excess air (c) higher calorific value (use above data) (d) exhaust gas composition.

4. An analysis of an exhaust gas sample gave the following percentage values (dry basis): CO_2= 7.20, CO=1.00, O_2=10.00, N_2=81.8. (a) Express the volumetric composition on a mass basis, (b) Assuming that the fuel is a hydrocarbon, find its approximate formula and (c) estimate the calorific value of the fuel.

5. A coal sample has a mass analysis of 80.4% carbon, 3.9% hydrogen,5.0% oxygen, 1.1% nitrogen, 1.1% sulfur and the rest in noncombustible ash. For complete combustion with 120% of the theoretical amount of air, determine the air-fuel ratio on a mass basis.

6. A sample of coal has the following gravimetric composition: C= 87%, H_2 = 4%, rest ash. Find (a) Stochiometric air-fuel ratio, (b) calorific value. (c) If after combustion, the dry flue gas indicated a CO_2 content of 12.6%. Determine excess air factor.

7. Determine the enthalpy carried away by an exhaust gas at 500 K if it has the following composition: CO_2 12.32 %, CO 1.68 %, O_2 2.99 %, N_2 76.38 %, and H_2O 6.63 %. Assume that the reference temperature is 298 K.

8. Determine the constant pressure Adiabatic Flame temperature (at 1 atm) for the combustion of a CH_4-air mixture if :

   - the mixture is stoichiometric and initial reactant temperature is 298 K.
   - 50% excess air is provided and initial reactant temperature is 298 K.
   - the mixture is stoichiometric and initial reactant temperature is 500 K.

9. Gaseous fuel containing 60% ethane and 40% methane by volume is burnt with 20 % excess air. Compute the adiabatic flame temperature if initially the reactants are at 25 °C.

10. Propane (C_3H_8) is burnt with stoichiometric air in a constant volume cylinder such that no heat escapes from the cylinder. If the initial temperature of the mixture is 200 °C, what is the final temperature of the products.

11. Air enriched with Oxygen is stored in a cylinder such that the O_2 to N_2 ratio is 1:2 (rather than 1:3.76 that is available in the surrounding air). If acetylene is burnt with this air in a stoichiometric amount what is the adiabatic flame temperature? You can assume that initial temperature of the reactants is 25°C.

12. Methane (CH_4) at 25^oC, enters the combustor of a simple open gas turbine power plant and burns completely with 400% of theoretical air entering the compressor at 25 °C, 1 atm. Products of combustion exit the turbine at 577 °C, 1 atm. The rate of heat transfer from the gas turbine is estimated as 10% of the net power developed. Determine the net power output, in MW, if the fuel mass flow rate is 1200 kg/h. Kinetic and potential energy effects are negligible.

13. A closed, rigid vessel initially contains a gaseous mixture of 1kmol of pentane (C_5H_{12}) and 150% of theoretical air at 25 °C, 1 atm. If the mixture burns completely, determine the heat transfer from the vessel, in kJ, and the final pressure, in atm, for a final temperature of 800K.

14. Methane (CH_4) at 25 °C, 1 atm enters an insulated reactor operating at steady state and burns with the theoretical amount of air entering at 25 °C, 1 atm. The products contain CO_2, CO, H_2O, O_2 and N_2 and exit at 2260K. Determine the fraction of the entering carbon in the fuel that burn to CO_2 and CO respectively