Thermodynamics for Aerospace Engineers (AS1300)
Assignment-1 (10 Apr 2019)
Total: 20, Weightage: 10, Due: 27 Apr 2019 2pm, (electronically)

Note: The assignment must be submitted electronically through '.pdf' file by email to only *tmmuruganandam@gmail.com*, by the given deadline. emails sent to other IDs will not be considered and will be deleted. Date & time of email received decided your receipt time. Negative scores of -2 per half hour will be awarded for late entries in half hour blocks. So no point in sending any email after 4.5 hours. IF two answer scripts show any evidence of copying, then the scores will be deducted and 'DisCo' invoked.

1. A Humphrey cycle is a variant of a Brayton cycle, with a constant volume heating in place of a constant pressure heating in Brayton cycle. This cycle is the thermodynamic standard cycle for the pulsed detonation engines (PDEs). The processes are:
(a) Reversible, adiabatic (isentropic) compression of the incoming gas. During this step incoming gas is compressed almost isentropically. Static pressure and density of the gas increase.
(b) Constant-volume heat addition. In this step, heat is added while the gas is kept at constant volume. This is achieved by a detonation wave, which is a very fast moving combustion wave.
(c) Reversible, adiabatic (isentropic) expansion of the gas. During this step incoming gas is expanded isentropically, producing work output. Static pressure and density of the gas decrease.
(d) Constant-pressure heat rejection. The gas is finally rejected into the atmosphere at the same pressure as the incoming gas.
(i) Show the TS diagram and PV diagram of this cycle. [2]
(ii) Find the work and heat interaction of the mass of gas in the cycle, for each of the individual processes. [4]
(iii) Find the net heat and work interactions for the whole cycle. [2]
(iv) Find the efficiency of the cycle and compare it to the Brayton cycle and the Carnot cycle. Explain the differences. [3]

2. Balance the following chemical reactions: [3]
(i) $C_6H_6 + (O_2+3.76\ N_2) \Rightarrow CO_2 + H_2O + N_2$
(ii) $C_6H_5NO_2 + (O_2+3.76\ N_2) \Rightarrow CO_2 + H_2O + N_2$
(iii) $15\ C_{12}H_{24} + 1\ C_6H_6 + (O_2+3.76\ N_2) \Rightarrow CO_2 + H_2O + N_2$
(iv) $SiH_4 + O_2 \Rightarrow SiO_2 + H_2O$
(v) $C_2H_6 + 5\ O_2 \Rightarrow CO_2 + H_2O + H_2 + CO + O_2$
(vi) $C_7H_{16} + 6.5\ O_2 \Rightarrow CO_2 + H_2O + H_2 + CO + O_2$

3. Find the Adiabatic flame temperature for the reactants in the proportions below. Explain the differences. Assume the reaction goes to the fullest extent possible to CO_2 and H_2O, and the rest are in the form of CO, H_2 and O_2. [6]
(i) $CH_4 + 2\ O_2$, (ii) $0.7\ CH_4 + 2\ O_2$, and (iii) $1.8\ CH_4 + 2\ O_2$

[BONUS]
B1. Repeat the problem for $1.06\ CH_4 + 2\ O_2$. Explain the trend with that in Q4. [2]

B2. There are two rooms A&B in a house, which is isolated except for electrical supply. Room A is heated by a reverse heat engine, by using the room B as a cold reservoir, using electrical power. At the same time, another heat exchanger based on water circulation which takes heat from Room A to room B, using water pump which uses electricity. Assume there is no conduction between the two rooms through walls. If the C.O.P of the heat pump (QH/W) is 'x', the water flow rate is 'm_dot'. Assume the efficiency of the heat exchanger is 1. Find the energy required to sustain the temperatures of the rooms at T_A and T_B. Find the entropy change for each of the rooms. When will this system achieve steady state? Explain. [5]