Assignment No. 8

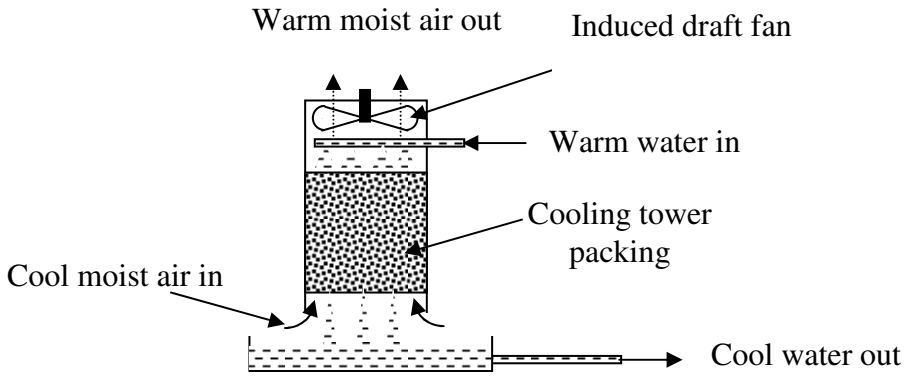
1. Two insulated tanks A and B are connected by a valve. Tank A has a volume of 2 m^3 and initially contains oxygen at 400 kPa, 10^0 C. Tank B has a volume of 10 m^3 and initially contains nitrogen at 200 kPa, 50^0 C. The valve is now opened and remains open until the resulting gas mixture comes to a uniform state. Determine
   (a) the final pressure and temperature
   (b) The entropy change for the process.
   (Ans.(a)233kPa,310.5K, (b)6.238 kJ/K)
2. Hydrogen and nitrogen are mixed in an adiabatic, steady- flow process in the ratio 2 kmol of hydrogen per kmol of nitrogen. The hydrogen enters at 500 kPa, 20^0 C, and the nitrogen enters at 500 kPa, 200^0C. The pressure after mixing is 490 kPa. Determine the temperature of the mixture and the net entropy change per kmol of mixture.
   (Ans. 353.9 K, 6.228 kJ/kmol K)
3. The products of combustion of a hydrocarbon fuel with air are analyzed, with the result as follows;

Compound	Percent by volume
CO_2	10.4
CO	0.1
H_2O	11.8
O_2	3.4
N_2	74.3

   This gas mixture passes through a heat exchanger at ambient pressure at the rate of 0.1 kg/s. What is the dew point temperature? If the mixture is cooled 10 ^{0}C below the dew point temperature, how long it will take to collect 10 kg of liquid water?
   (Ans. 49 ^{0}C, 55 min)
4. An air-water vapour mixture enters an air- conditioning unit at 110 kPa, 30 ^{0}C, with a relative humidity of 50%. The mass flow rate of dry air entering the unit is 1 kg/s. The air-vapour mixture leaves the air-conditioning unit at 105 kPa, 10 ^{0}C, with a relative humidity of 100% and liquid condensate also leaves the unit at 10 ^{0}C. Determine the rate of heat transfer for this process.
   (Ans. –32.61 kW)
5. A combination air cooler and dehumidification unit receives outside ambient air at 35 ^{0}C, 100 kPa, 90% relative humidity. This air-water vapour mixture is first cooled to a low temperature to condense the proper amount of water, after which the air-vapour mixture is heated, leaving the unit at 20 ^{0}C, 100 kPa, 30% relative humidity. The volume flow rate of the air-vapour mixture at the exit conditions is 0.01 m^3/s.
   (a) Find the temperature to which the mixture is initially cooled, and the mass of water condensed per kilogram of dry air. Show the process that the water undergoes on a T-s diagram.
   (b) Assuming that all the liquid water condensed leaves the unit at the minimum temperature, calculate the over all heat transfer rate.
   (Ans. (a) 1.7^{0}C, 0.02879 kg, (b) –1.05 kW)
6. Ambient air at 100 kPa, 30^0C, 40% relative humidity, is to be conditioned to 100 kPa, 20^0C, 50% relative humidity, in the following manner. One stream is cooled at constant pressure to 5^0C, and any liquid water condensate is trapped out. The air-vapour stream from this cooler is then mixed with an unconditioned stream to produce the desired state. Calculate the following:

(a) The ratio of the mass flow rates of the two streams.
(b) The required heat transfer in the cooler.
(Ans. (a) 0.559, (b) –38.7 kJ/kg air)

7. A problem of current interest is that of thermal pollution of river and lake water by using the water for power plant condenser cooling water and then returning it to the source at a higher temperature. The use of a cooling tower presents a solution to this particular problem. Consider the case shown in Fig. 1, in which 2.5 kg/s of water at 40^0C (from the condenser) enters the top of the cooling tower, and the cooled water leaves the bottom at 20^0C. The air-water vapour mixture enters the bottom of the cooling tower at 100 kPa, and has a dry bulb temperature of 22^0C and relative humidity of 48%. The air-water mixture leaves the tower at 95 kPa, 30^0C, with a relative humidity of 80%. Determine the kilograms of dry air per second that must be used and the fraction of the incoming water that evaporates. Assume the process to be adiabatic.
(Ans. 4.584 kg/s, 0.0278)



8. One means of condensing steam during an emergency blow down of a nuclear reactor is by use of a containment vessel as shown in the figure. The vessel is insulated and has a total volume of 30 m^3, with liquid water initially occupying 1m^3. The initial state inside the vessel is 35 ^{0}C, 100 kPa. Now, during a short period of time, 55 kg of water enters the vessel at an average state of P_i=700 kPa, x_i=0.5. Find the temperature and pressure inside the vessel at the end of this period of time. (Ans. 53.9^0C, 116 kPa)