**Assignment-7**

**Note:** Unless explicitly specifies otherwise, the reference dead state shall be 1 bar 300K.

1. Determine the maximum useful work that can be obtained when the following systems are brought in equilibrium with the surroundings.

A) 1 kg of water substances at 8 bar as saturated vapour (607.6 kJ)

B) 1 kg of water substance at 8 bar, 500$^{o}$C (815.7 kJ)

2. Two identical bodies of the same mass and heat capacity $C_{p,}$ initially at temperature $T_A$ and $T_B$ respectively and initial pressure $P_0$ are allowed to come to thermal equilibrium with each other. Compute the maximum possible work that can be extracted.
   $\left(W_{u-\max} = Mc_p \left[(T_A + T_B) - 2\sqrt{T_A T_B}\right]\right)$.
3. A). Calculate the maximum possible work that can be extracted from an adiabatic steam turbine, if the inlet state of the steam is 7 bar 250$^{o}$ C, the exit pressure is 1 bar and the mass flow rate is 5 kg/s. (1866 kW).
   B). Rework the same problem if there is a heat loss of 30 kJ per kg of steam flow from the turbine to ambient at 300 K. If the second law efficiency for the turbine is defined as the ratio of useful work extracted per unit mass of the steam to the decrease in the exergy of the steam, find the same for both the previous part and this part. (1902 kW, 100%, 100%).
4. Air at 1000 K at 10 bar expands in an adiabatic turbine to 1 bar with an isentropic efficiency of 0.8. If the air flow rate is 2 kg.s, determine a) Power output b) Maximum possible power output for the same inlet and exit conditions, c) lost power and d) second law efficiency as defined in the previous problem. (773.7 kW, 876.4 kW, 102.7 kW, 88.28%)
5. A system is consisting of 1 kg water substance is compressed from 15 bar, 250 $^{o}$C to 20 bar quasi-statically and isothermally, while being cooled by the environment. Determine a) Useful work done by the system, b) maximum useful work, c) Lost work and d) the second law efficiency for the compressor which is defined as the ratio of the increase of exergy to the work input per unit mass flow of the fluid. [Note: the definition here is the inverse of what was defined for the turbine]. (-67.65 kJ, -29.4 kJ, 38.25 kJ, 43.4%)
6. Two alternative systems operating at steady state are in consideration for heating air form 17$^{o}$C to 52$^{o}$C at essentially constant pressure of 1 bar, the system operate as follows. In system-1 the air temperature is increased as a consequence of an electric heater inside, while in system-2 the air is heated in a heat exchanger by steam condensing at 1 bar. On the basis of thermodynamic principles. Which of these systems is the preferred one? You may neglect the change in kinetic and potential energies in your analysis. [The solution for such problems is obtained from second law efficiency]. ($\eta_{II}$ for system –1=2.32%, $\eta_{II}$ for system-2= 11.85%).
7. In the boiler of the power plant are tubes in which water is heated at constant pressure from 150$^{o}$C to 240$^{o}$C at essentially constant pressure of 0.8 Mpa. The combustion gases that heat the water can be modelled as air which get cooled from 1067$^{o}$C to 547$^{o}$C essentially at constant pressure. Assuming that there is no heat loss from the boiler, and that the kinetic and potential energy effects can be neglected, determine a) the mass flow rate of the combustion gasses in kg/kg of the steam flowing, b) the irreversibility rate in kJ/kg of the steam flowing, c) the second law efficiency defined as the product of the ratio of the increase in energy of the cold stream to the decrease in exergy of the hot stream and the ratio of cold stream mass flow to the hot stream mass flow.