**IIT Mandi**

**Engineering Thermodynamics**

**Tutorial-7**

1. A first stage in a turbine receives steam at 10 MPa, 800°C with an exit pressure of 800 kPa. Assume the stage is adiabatic and negelect kinetic energies. Find the exit temperature and the specific work. Ans: 350, 954
2. A boiler section boils 3 kg/s saturated liquid water at 2000 kPa to saturated vapor in a reversible constant pressure process. Assume you do not know that there is no work. Prove that there is no shaft work using the first and second laws of thermodynamics.
3. Consider the design of a nozzle in which nitrogen gas flowing in a pipe at 500 kPa, 200°C, and at a velocity of 10 m/s, is to be expanded to produce a velocity of 300 m/s. Determine the exit pressure and cross-sectional area of the nozzle if the mass flow rate is 0.15 kg/s, and the expansion is reversible and adiabatic.357.6 kPa, 1.78 E-4 m2
4. A compressor receives air at 290 K, 100 kPa and a shaft work of 5.5 kW from a gasoline engine. It should deliver a mass flow rate of 0.01 kg/s air to a pipeline. Find the maximum possible exit pressure of the compressor. 4.1 MPa
5. A flow of 2 kg/s saturated vapor R-22 at 500 kPa is heated at constant pressure to 60oC. The heat is supplied by a heat pump that receives heat from the ambient at 300 K and work input. Assume everything is reversible and find the rate of work input. 0.7 kW
6. Consider a steam turbine power plant operating near critical pressure. As a first approximation, it may be assumed that the turbine and the pump processes are reversible and adiabatic. P=22 MPa, T=700 oC at turbine inlet. P=20 kPa at turbine exit. Neglecting any changes in kinetic and potential energies, calculate
   * 1. The specific turbine work output and the turbine exit state
     2. The pump work input and enthalpy at the pump exit state -20.1, 187.6
     3. The thermal efficiency of the cycle 0.428
7. A two-stage compressor having an inter stage cooler takes in air, 300 K, 100 kPa, and compresses it to 2 MPa. The cooler then cools the air to 340 K, after which it enters the second stage, which has an exit pressure of 15.74 MPa. Both stages are adiabatic, and reversible. Find q in the cooler, total specific work, and compare this to the work required with no intercooler. -682.8 kJ/kg with intercooler, -978.8 kJ/kg without IC
8. Steam enters a turbine at 300°C, 600 kPa and exhausts as saturated vapor at 20 kPa. What is the isentropic efficiency?
9. Repeat Problem 6 assuming the turbine and the pump each have an isentropic efficiency of 85%. Thermal efficiency = 36.2%