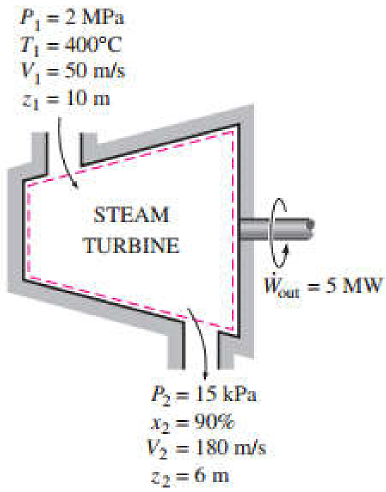
Course : Applied Thermal Engineering (UMT303)

Batch: B.E. Mechatronics (2nd yr.) **Faculty: Dr. Sayan Sadhu**

Tutorial No. 04 **Topic: Open System Energy Analysis**

Q1. Air at 10°C and 80 kPa enters the diffuser of a jet engine steadily with a velocity of 200 m/s. The inlet area of the diffuser is 0.4 m^2. The air leaves the diffuser with a velocity that is very small compared with the inlet velocity. Determine (a) the mass flow rate of the air and (b) the temperature of the air leaving the diffuser **[Ans. 78.8kg/s, 303K]**

Q2. The power output of an adiabatic steam turbine is 5 MW, and the inlet and the exit conditions of the steam are as indicated in figure below. (a) Compare the magnitudes of h, ke, and pe. (b) Determine the work done per unit mass of the steam flowing through the turbine. (c) Calculate the mass flow rate of the steam.
[Ans. -887.39kJ/kg, 14.95 kJ/kg, -0.04 kJ/kg, 872.48 kJ/kg, 5.73 kg/s]



Q3. Refrigerant-134a is to be cooled by water in a condenser. The refrigerant enters the condenser with a mass flow rate of 6 kg/min at 1 MPa and 70°C and leaves at 35°C. The cooling water enters at 300 kPa and 15°C and leaves at 25°C. Neglecting any pressure drops, determine (a) the mass flow rate of the cooling water required and (b) the heat transfer rate from the refrigerant to water. **[Ans. 29.1 kg/min, 1218kJ/min]**

Q4. A certain pressure cooker has a volume of 6 L and an operating pressure of 75 kPa gage. Initially, it contains 1 kg of water. Heat is supplied to the pressure cooker at a rate of 500 W for 30 min after the operating pressure is reached. Assuming an atmospheric pressure of 100 kPa, determine (a) the temperature at which cooking takes place and (b) the amount of water left in the pressure cooker at the end of the process. **[Ans. 116.04°C, 0.6 kg]**

Q5. Steam enters a converging–diverging nozzle operating at steady state with p1 = 40 bar, T1 = 400°C, and a velocity of 10 m/s. The steam flows through the nozzle with negligible heat transfer and no significant change in potential energy. At the exit, p2 = 15 bar, and the velocity is 665 m/s. The mass flow rate is 2 kg/s. Determine the exit area of the nozzle, in m^2.
[Ans. 0.0489 mm^2]

Q6. Air enters a compressor operating at steady state at a pressure of 1 bar, a temperature of 290 K, and a velocity of 6 m/s through an inlet with an area of 0.1 m^2. At the exit, the pressure is 7 bar, the temperature is 450 K, and the velocity is 2 m/s. Heat transfer from the compressor to its surroundings occurs at a rate of 180 kJ/min. Employing the ideal gas model, calculate the power input to the compressor, in kW. **[Ans. 119.4kW]**

Q7. Steam enters the condenser of a vapor power plant at 0.1 bar with a quality of 0.95 and condensate exits at 0.1 bar and 45°C. Cooling water enters the condenser in a separate stream as a liquid at 20°C and exits as a liquid at 35°C with no change in pressure. Heat transfer from the outside of the condenser and changes in the kinetic and potential energies of the flowing streams can be ignored. For steady-state operation, determine (a) the ratio of the mass flow rate of the cooling water to the mass flow rate of the condensing steam. (b) the energy transfer from the condensing steam to the cooling water, in kJ per kg of steam passing through the condenser. **[Ans. 36.3, 2276.7 kJ/kg]**

Q8. A tank having a volume of 0.85 m^3 initially contains water as a two-phase liquid–vapor mixture at 260°C and a quality of 0.7. Saturated water vapor at 260°C is slowly withdrawn through a pressure-regulating valve at the top of the tank as energy is transferred by heat to maintain constant pressure in the tank. This continues until the tank is filled with saturated vapor at 260°C. Determine the amount of heat transfer, in kJ. Neglect all kinetic and potential energy effects. **[Ans. 14162 kJ]**