INDIAN INSTITUTE OF TECHNOLOGY KANPUR

ESO 201A: Thermodynamics

(2023-24 I Semester)

Instructor: Dr Avinash Kumar Agarwal

Tutorial 5

Question 1: An insulated piston–cylinder device contains 5 L of saturated liquid water at a constant pressure of 175 kPa. Water is stirred by a paddle wheel while a current of 8 A flows for 45 min through a resistor placed in the water. If one-half of the liquid is evaporated during this constant-pressure process and the paddle-wheel work amounts to 400 kJ, determine the voltage of the source. Also, show the process on a p-V diagram with respect to saturation lines. **(Ans. 224V)**

Question 2: Steam at 75 kPa and 8 percent quality is contained in a spring-loaded piston–cylinder device, as shown in Fig.1, with an initial volume of 2 m^3. Steam is now heated until its volume is 5 m^3 and its pressure is 225 kPa. Determine the heat transferred to and the work produced by the steam during this process. **(Ans. 450 kJ and 12750 kJ)**

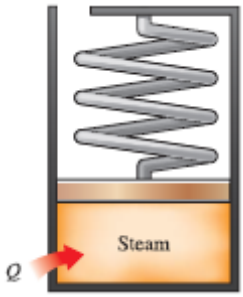

Figure 1.

Question 3: Air enters the 1-m^2 inlet of an aircraft engine at 100 kPa and 20°C with a velocity of 180 m/s. Determine the volume flow rate, in m3/s, at the engine's inlet and the mass flow rate, in kg/s, at the engine's exit. **(Ans. 180 m^3/s and 214.1 kg/s)**

Question4: Air enters a nozzle steadily at 2.21 kg/m^3 and 40 m/s and leaves at 0.762 kg/m3 and 180 m/s. If the inlet area of the nozzle is 90 cm^2, determine (a) the mass flow rate through the nozzle, and (b) the exit area of the nozzle. **(Ans. 0.796 kg/s and 58.0 cm^2)**

Question5: A spherical hot-air balloon is initially filled with air at 120 kPa and 20°C with an initial diameter of 5 m. Air enters this balloon at 120 kPa and 20°C with a velocity of 3 m/s through a 1-m-diameter opening. How many minutes will it take to inflate this balloon to a 17-m diameter when the pressure and temperature of the air in the balloon remain the same as the air entering the balloon? **(Ans. 17.7 min)**

Question6: Refrigerant-134a enters a diffuser steadily as saturated vapor at 600 kPa with a velocity of 160 m/s, and it leaves at 700 kPa and 40°C. The refrigerant is gaining heat at a rate of 2 kJ/s as it passes through the diffuser. If the exit area is 80 percent

greater than the inlet area, determine (a) the exit velocity and (b) the mass flow rate of the refrigerant. **(Ans. (a) 82.1 m/s, (b) 0.298 kg/s)**

Question7: Refrigerant-134a enters a compressor at 180 kPa as a saturated vapor with a flow rate of 0.35 m^3/min and leaves at 900 kPa. The power supplied to the refrigerant during the compression process is 2.35 kW. What is the temperature of R-134a at the exit of the compressor? **(Ans. 52.5°C)**