INDIAN INSTITUTE OF TECHNOLOGY KANPUR

ESO 201A: Thermodynamics

(2023-24 I Semester)

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Tutorial 7

Question 1: A well-insulated rigid tank contains 3 kg of a saturated liquid–vapor mixture of water at 200 kPa. Initially, three quarters of the mass is in the liquid phase. An electric resistance heater placed in the tank is now turned on and kept on until all the liquid in the tank is vaporized. Determine the entropy change of the steam during this process. **(Ans: 11.1 kJ/K)**

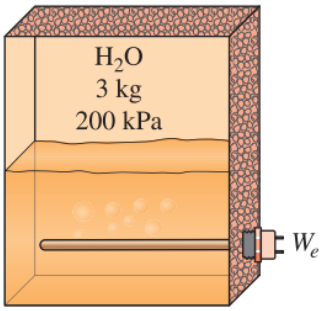

Fig. 1

Question 2: A piston–cylinder device contains 5 kg of steam at 100°C with a quality of 50 percent. This steam undergoes two processes as follows:

1-2: Heat is transferred to the steam in a reversible manner while the temperature is held constant until the steam exists as a saturated vapor.

2-3: The steam expands in an adiabatic, reversible process until the pressure is 15 kPa.

(a) Sketch these processes with respect to the saturation lines on a single T-s diagram.

(b) Determine the heat transferred to the steam in process 1-2, in kJ.

(c) Determine the work done by the steam in process 2-3, in kJ.

(Ans: (b) 5641 kJ (c) 1291 kJ)

Question 3: Helium gas is compressed from 90 kPa and 30°C to 450 kPa in a reversible, adiabatic process. Determine the final temperature and the work done, assuming the process takes place (a) in a piston–cylinder device and (b) in a steady-flow compressor. **(Ans: (a) 576.9 K, 853.4 kJ/kg (b) 1422.3 kJ/kg)**

Question 4: Nitrogen gas is compressed from 80 kPa and 27°C to 480 kPa by a 10-kW compressor. Determine the mass flow rate of nitrogen through the compressor, assuming the compression process to be (a) isentropic, (b) polytropic with n = 1.3, (c) isothermal, and (d) ideal two-stage polytropic with n = 1.3. **(Ans: (a) 0.048 kg/s (b) 0.051 kg/s (c) 0.063 kg/s (d) 0.056 kg/s)**

Question 5: Hot combustion gases enter the nozzle of a turbojet engine at 260 kPa, 747°C, and 80 m/s, and they exit at a pressure of 85 kPa. Assuming an isentropic efficiency of 92 percent and treating the combustion gases as air, determine (a) the exit velocity and (b) the exit temperature. **(Ans: (a) 728 m/s (b) 786 K)**

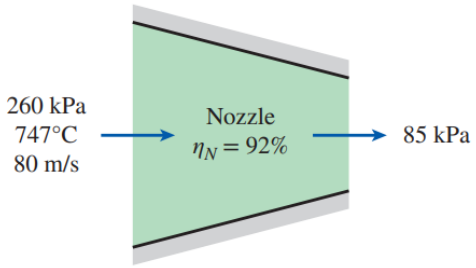

Fig. 2