INDIAN INSTITUTE OF TECHNOLOGY KANPUR

ESO 201A: Thermodynamics

(2023-24 I Semester)

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Tutorial 3

Question 1: At a certain location, wind is blowing steadily at 7 m/s. Determine the mechanical energy of air per unit mass and the power generation potential of a wind turbine with 80-m-diameter blades at that location. Also determine the actual electric power generation assuming an overall efficiency of 30 percent. Take the air density to be 1.25 kg/m^3. **(Ans. 1078 kW, 323 kW)**

Question 2: Water is pumped from a lower reservoir to a higher reservoir by a pump that provides 20 kW of shaft power. The free surface of the upper reservoir is 45 m higher than that of the lower reservoir. If the flow rate of water is measured to be 0.03 m^3/s, determine mechanical power that is converted to thermal energy during this process due to frictional effects. **(Ans. 6.8 kW)**

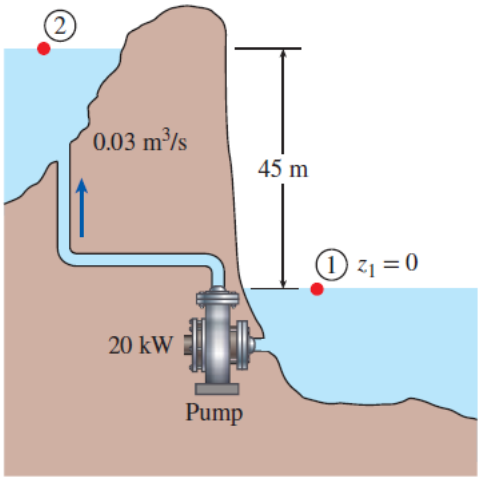

Fig. 1

Question 3: A 1.8-m^3 rigid tank contains steam at 220°C. One-third of the volume is in the liquid phase and the rest is in the vapor form. Determine (a) the pressure of the steam, (b) the quality of the saturated mixture, and (c) the density of the mixture. **(Ans. 2320 kPa, 0.0269, 287.8 kg/m^3)**

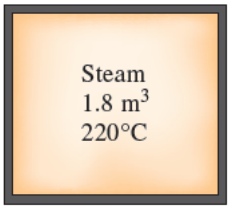

Fig. 2

Question 4: 10 kg of R-134a fill a 1.115-m^3 rigid container at an initial temperature of –30°C. The container is then heated until the pressure is 200 kPa. Determine the final temperature and the initial pressure. **(Ans. 14.2°C, 84.43 kPa)**

Question 5: 100 kg of R-134a at 200 kPa are contained in a piston–cylinder device whose volume is 12.322 m^3. The piston is now moved until the volume is one-half its original size. This is done such that the pressure of the R-134a does not change. Determine the final temperature and the change in the total internal energy of the R-134a.

(Ans. -10.09°C, -110.6 kJ/kg)

Question 6: Water initially at 200 kPa and 300°C is contained in a piston–cylinder device fitted with stops. The water is allowed to cool at constant pressure until it exists as a saturated vapor and the piston rests on the stops. Then the water continues to cool until the pressure is 100 kPa. On the *T*-*v* diagram, sketch, with respect to the saturation lines, the process curves passing through the initial, intermediate, and final states of the water. Label the *T, P,* and *v* values for end states on the process curves. Find the overall change in internal energy between the initial and final states per unit mass of water. **(Ans. 1300 kJ/kg)**

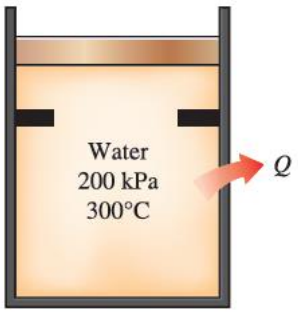

Fig. 3