INDIAN INSTITUTE OF TECHNOLOGY KANPUR

ESO 201A: Thermodynamics

(2023-24 I Semester)

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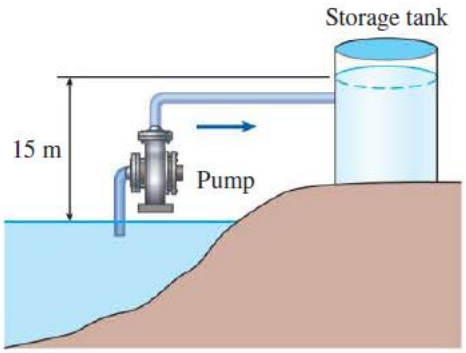
Practice Problems - Set 3

Problem 1: Water is pumped from a lake to a storage tank 15 m above at a rate of 70 L/s while consuming 15.4 kW of electric power. Disregarding any frictional losses in the pipes and any changes in kinetic energy, determine (a) the overall efficiency of the pump–motor unit and (b) the pressure difference between the inlet and the exit of the pump.

(Ans. 66.9%, 147 kPa)



Problem 2: Large wind turbines with a power capacity of 8 MW and blade span diameters of over 160 m are available for electric power generation. Consider a wind turbine with a blade span diameter of 100 m installed at a site subjected to steady winds at 8 m/s. Taking the overall efficiency of the wind turbine to be 32 percent and the air density to be 1.25 kg/m^3, determine the electric power generated by this wind turbine. Also, assuming steady winds of 8 m/s during a 24-h period, determine the amount of electric energy and the revenue generated per day for a unit price of $0.09/kWh for electricity.

(Ans. 804.2 kW, 19,300 kWh, $1737 (per day))

Problem 3: A piston–cylinder device contains 0.85 kg of refrigerant- 134a at –10°C. The piston that is free to move has a mass of 12 kg and a diameter of 25 cm. The local atmospheric pressure is 88 kPa. Now, heat is transferred to refrigerant-134a until the temperature is 15°C. Determine (a) the final pressure, (b) the change in the volume of the cylinder, and (c) the change in the enthalpy of the refrigerant-134a. **(Ans. 90.4 kPa, 0.0205 m^3, 17.4 kJ/kg)**

Problem 4: A piston–cylinder device contains 0.6 kg of steam at 300°C and 0.5 MPa. Steam is cooled at constant pressure until one-half of the mass condenses.

(a) Show the process on a T-v diagram.

(b) Find the final temperature.

(c) Determine the volume change.

(Ans. 151.83°C, -0.2008 m^3)

Problem 5: The spring-loaded piston–cylinder device shown in Fig. 2 is filled with 0.5 kg of water vapor that is initially at 4 MPa and 400°C. Initially, the spring exerts no force against the piston. The spring constant in the spring force relation F = kx is k = 0.9 kN/cm and the piston diameter is D = 20 cm. The water now undergoes a process until its volume is one-half of the original volume. Calculate the final temperature and the specific enthalpy of the water. **(Ans. 220°C, 1721 kJ/kg)**

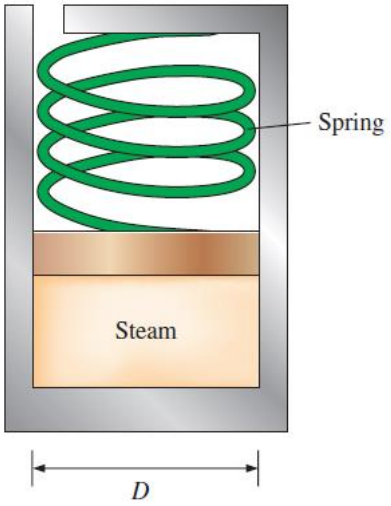


Fig.2