Course : Applied Thermal Engineering (UMT303)

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

Tutorial No. 03 **Topic: Closed System Energy Analysis**

Q1. A piston–cylinder device contains 0.05 m^3 of a gas initially at 200 kPa. At this state, a linear spring that has a spring constant of 150 kN/m is touching the piston but exerting no force on it. Now heat is transferred to the gas, causing the piston to rise and to compress the spring until the volume inside the cylinder doubles. If the cross-sectional area of the piston is 0.25 m^2, determine (a) the final pressure inside the cylinder, (b) the total work done bythe gas, and (c) the fraction of this work done against the spring to compress it.

[Ans 320kPa, 13kJ, 3kJ]

Q2. A piston–cylinder device contains 25 g of saturated water vapor that is maintained at a constant pressure of 300 kPa. A resistance heater within the cylinder is turned on and passes a current of 0.2 A for 5 min from a 120-V source. At the same time, a heat loss of 3.7 kJ occurs. (a) Show that for a closed system the boundary work Wb and the change in internal energy U in the first-law relation can be combined into one term, H, for a constant pressure process. (b) Determine the final temperature of the steam. **[Ans 200^{o}C]**

Q3. A rigid tank is divided into two equal parts by a partition. Initially, one side of the tank contains 5 kg of water at 200 kPa and 25°C, and the other side is evacuated. The partition is then removed, and the water expands into the entire tank. The water is allowed to exchange heat with its surroundings until the temperature in the tank returns to the initial value of 25°C. Determine (a) the volume of the tank, (b) the final pressure, and (c) the heat transfer for this process. **[Ans 0.01m^3, 3.1698kPa, 0.25kJ]**

Q4. Air at 300 K and 200 kPa is heated at constant pressure to 600 K. Determine the change in internal energy of air per unit mass, using (a) data from the air table (b) the functional form of the specific heat and (c) the average specific heat value.

[Ans 220.71kJ/kg, 222.5kJ/kg, 220kJ/kg]

Q5. A piston–cylinder device initially contains air at 150 kPa and 27°C. At this state, the piston is resting on a pair of stops, and the enclosed volume is 400 L. The mass of the piston is such that a 350-kPa pressure is required to move it. The air is now heated until its volume has doubled. Determine (a) the final temperature, (b) the work done by the air, and (c) the total heat transferred to the air. **[Ans 1400K, 140kJ, 767kJ]**

Q6. One-tenth milliliter of cooking oil is placed in the chamber of a constant-volume calorimeter filled with sufficient oxygen for the oil to be completely burned. The chamber is immersed in a water bath. The mass of the water bath is 2.15 kg. For the purpose of this analysis, the metal parts of the apparatus are modeled as equivalent to an additional 0.5 kg of water. The calorimeter is well insulated, and initially the temperature throughout is 258C. The oil is ignited by a spark. When equilibrium is again attained, the temperature throughout is 25.38C. Determine the change in internal energy of the chamber contents, in kcal per mL of cooking oil and in kcal per tablespoon of cooking oil. **[Ans 7.9kCal/ml]**