Saylor Foundation's

ME103 Assessment, Unit 6: Guide to Responding

Instructions: Please answer each of the following questions to the best of your ability.

Questions:

1. Consider an air-standard Otto-cycle engine with a compression ratio of 8. At the beginning of compression, the pressure and temperature at the beginning of compression are 100 kPa and 300 K, respectively. Determine the thermal efficiency of the engine if 1.8 kJ is added per kg air and C_v = 0.7165 J/kg

2. Determine the thermal efficiency of a Carnot steam cycle operating between a source temperature of 583 K and a sink temperature of 306 K. The boiler and condenser pressures are 10 MPa and 5 kPa, respectively.

Solutions:

1. Draw the Otto cycle.

   - At State 1, P_1 = 100 kPa and T_1 = 300 K.
   - At State 2, $P_2 = P_1 \mu^k$ and $T_2/T_1 = (P_2/P_1)^{k-1/k} = \mu^{k-1}$, where µ is the compression ratio and k is 1.4 for air. This give P_2 = 1840 kPa and T_2= 689 K.
   - At State 3, heat is added to air at $q_H = C_{vn}(T_3 - T_2)$ = 1800. This gives T_3 = 3196 K. $P_3 = P_2(T_3/T_2)$ = 8524 K
   - At State 4, applying the Otto cycle equations, we obtain P_4 = 464 kPa and T_4 = 1391 K.

   The thermal efficiency of the engine is:

   $n_{th} = 1 - q_L/q_H = 1 - C_v(T_4 - T_1)/q_H = 0.56$

2. Draw the Otto engine cycle and define states 1-4 clearly.

   Use steam tables to look up properties of different states along the vapor cycle. For states 1 and 4, water is saturated.

   - At state 2, H_2 = 1407 kJ/kg, s_2= 3.36 kJ/kg K
   - At state 3, H_3= 2725 kJ/kg, s_3= 5.61 kJ/kg K
   - At state 1, x_1 =0.36, $H_1 = h_{f,1} + x_1 h_{fg,1}$ =1020 kJ/kg
   - At state 4, x_1 =0.65, $H_4 = h_{f,4} + x_4 h_{fg,4}$ =1711 kJ/kg

   Thermal efficiency is given by $N_{th} = w_{net}/q_H = (w_T - w_c)/q_H$

   - turbine work $w_T = h_3 - h_4$
   - compressor work: $w_c = h_2 - h_1$
   - heat added: $q_H = h_3 - h_2$

   Hence, thermal efficiency $N_{th} = w_{net}/q_H = (w_T - w_c)/q_H = 1 - (h_1 - h_4)/(h_3 - h_2) = 0.48$