ME 6101: Classical Thermodynamics

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1. A heat engine that receives heat from a furnace 1200°C and rejects waste heat to a river at 20°C has a thermal efficiency of 40 percent. Determine the second-law efficiency of this power plant.

2. A house that is losing heat at a rate of 50,000 kJ/h when the outside temperature drops to 4°C is to be heated by electric resistance heaters. If the house is to be maintained at 25°C at all times, determine the reversible work input for this process and the irreversibility.

3. A turbine receives steam at 3000 kPa, 500°C and has two exit flows, one at 1000 kPa, 350°C with 20% of the flow and the remainder at 200 kPa, 200°C. Find the isentropic and second-law efficiencies.

4. Steam enters a turbine at 25 MPa, 550°C and exits at 5MPa, 325°C at a flow-rate of 70 kg/s. Determine the total power output of the turbine, its isentropic efficiency, and its second-law efficiency.

5. Air enters a compressor at ambient conditions of 100 kPa, 300 K and exits at 800 kPa. If the isentropic compressor efficiency is 85%, what is the second-law efficiency of the compressor process?

6. A compressor is used to bring saturated water vapor at 1 MPa up to 15 MPa, where the actual exit temperature is 650°C. Find the irreversibility and the second-law efficiency.

7. A heat exchanger brings 10 kg/s water from 100°C up to 500°C at 2000 kPa using air coming in at 1400 K and leaving at 460 K. What is the second-law efficiency?

8. Saturated R-134a vapour enters the adiabatic compressor of vapour compression refrigeration cycle at 0.2 MPa and leaves the condenser as a saturated liquid at 0.8 MPa. The temperature of the vapor leaving the irreversible compressor is 44°C and the ambient temperature is 25°C. Determine the energy and availability changes and irreversibilities around the cycle.

9. Refrigerant-134a at 1 MPa and 100°C is throttled to a pressure of 0.8 MPa. Determine the reversible work and exergy destroyed during this throttling process. Assume the surroundings to be at 30°C.

10. Steam enters an adiabatic nozzle at 3.5 MPa and 300°C with a low velocity and leaves at 1.6 MPa and 250°C at a rate of 0.4 kg/s. If the ambient state is 100 kPa and 18°C, determine (a) the exit velocity, (b) the rate of exergy destruction, and (c) the second-law efficiency.