Course : Applied Thermal Engineering (UMT303)

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

Tutorial No. 07 **Topic: Exergy**

Q1. A 200-m^3 rigid tank contains compressed air at 1 MPa and 300 K. Determine how much work can be obtained from this air if the environment conditions are 100 kPa and 300 K.
[Ans. 281MJ]

Q2. Consider steady heat transfer through a 5-m x 6-m brick wall of a house of thickness 30 cm. On a day when the temperature of the outdoors is 0°C, the house is maintained at 27°C. The temperatures of the inner and outer surfaces of the brick wall are measured to be 20°C and 5°C, respectively, and the rate of heat transfer through the wall is 1035 W. Determine the rate of exergy destruction in the wall, and the rate of total exergy destruction associated with this heat transfer process. **[Ans. 52W, 93.2W]**

Q3. A piston–cylinder device contains 0.05 kg of steam at 1 MPa and 300°C. Steam now expands to a final state of 200 kPa and 150°C, doing work. Heat losses from the system to the surroundings are estimated to be 2 kJ during this process. Assuming the surroundings to be at T_0= 25°C and P_0 =100 kPa, determine (a) the exergy of the steam at the initial and the final states, (b) the exergy change of the steam, (c) the exergy destroyed, and (d) the second-law efficiency for the process. **[Ans. 35kJ, 25.4kJ, -9.6kJ, 4.3kJ, 55.2%]**

Q4. A 5-kg block initially at 350°C is quenched in an insulated tank that contains 100 kg of water at 30°C. Assuming the water that vaporizes during the process condenses back in the tank and the surroundings are at 20°C and 100 kPa, determine (a) the final equilibrium temperature, (b) the exergy of the combined system at the initial and the final states, and (c) the wasted work potential during this process. **[Ans. 31.7^{0}C, 315kJ, 95.6kJ, 219.4kJ]**

Q5. A frictionless piston–cylinder device, initially contains 0.01 m3 of argon gas at 400 K and 350 kPa. Heat is now transferred to the argon from a furnace at 1200 K, and the argon expands isothermally until its volume is doubled. No heat transfer takes place between the argon and the surrounding atmospheric air, which is at T_0 = 300 K and P_0 = 100 kPa. Determine (a) the useful work output, (b) the exergy destroyed, and (c) the reversible work for this process **[Ans. 1.43kJ, 1.22kJ/K, 2.65kJ]**

Q6. Steam enters a turbine steadily at 3 MPa and 450°C at a rate of 8 kg/s and exits at 0.2 MPa and 150°C. The steam is losing heat to the surrounding air at 100 kPa and 25°C at a rate of 300 kW, and the kinetic and potential energy changes are negligible. Determine (a) the actual power output, (b) the maximum possible power output, (c) the second-law efficiency, (d) the exergy destroyed, and (e) the exergy of the steam at the inlet conditions
[Ans. 4306kW, 4665kW, 92.3%, 359kW, 1238kJ/kg]

Q7. A 200-m^3 rigid tank initially contains atmospheric air at 100 kPa and 300 K and is to be used as a storage vessel for compressed air at 1 MPa and 300 K. Compressed air is to be supplied by a compressor that takes in atmospheric air at P_0 = 100 kPa and T_0 = 300 K. Determine the minimum work requirement for this process. **[Ans. 281MJ]**

Q8. Water initially a saturated liquid at $150^{o}C$ (423.15 K) is contained in a piston–cylinder assembly. The water is heated to the corresponding saturated vapor state in an internally reversible process at constant temperature and pressure. For T_0 = $20^{o}C$, p_0 = 1 bar, and ignoring the effects of motion and gravity, determine per unit of mass, each in kJ/kg, (a) the change in exergy, (b) the exergy transfer accompanying heat transfer, (c) the exergy transfer accompanying work, and (d) the exergy destruction.

[Ans. 502.38kJ/kg, 649.49kJ/kg, 147.21kJ/kg,0]

Q9. Compressed air enters a counterflow heat exchanger operating at steady state at 610 K, 10 bar and exits at 860 K, 9.7 bar. Hot combustion gas enters as a separate stream at 1020 K, 1.1 bar and exits at 1 bar. Each stream has a mass flow rate of 90 kg/s. Heat transfer between the outer surface of the heat exchanger and the surroundings can be ignored. The effects of motion and gravity are negligible. Assuming the combustion gas stream has the properties of air, and using the ideal gas model for both streams, determine for the heat exchanger (a) the exit temperature of the combustion gas, in K. (b) the net change in the flow exergy rate from inlet to exit of each stream, in MW. (c) the rate exergy is destroyed, in MW. Let T_0 = 300 K, p_0 = 1 bar. **[Ans. 505C, -16.93MW, 2.83MW]**