School of Mechanical Engineering
Engineering Thermodynamics-II, ME- 401
Assignment-II

4th Semester

Section 1: Gas Power Cycles

Q1. Air is used as the working fluid in a simple ideal Brayton cycle that has a pressure ratio of 12, a compressor inlet temperature of 300 K, and a turbine inlet temperature of 1000 K. Determine the required mass flow rate of air for a net power output of 70 MW, assuming both the compressor and the turbine have an isentropic efficiency of (a) 100 percent and (b) 85 percent. Assume constant specific heats at room temperature.
 Answers: (a) 352 kg/s, (b) 1037 kg/s

Q2. Air enters the compressor of a gas-turbine engine at 300 K and 100 kPa, where it is compressed to 700 kPa and 580 K. Heat is transferred to air in the amount of 950 kJ/kg before it enters the turbine. For a turbine efficiency of 86 percent, determine (a) the fraction of the turbine work output used to drive the compressor and (b) the thermal efficiency.

Q3. A gas-turbine power plant operates on the simple Brayton cycle between the pressure limits of 100 and 1200kPa. The working fluid is air, which enters the compressor at 30°C at a rate of 150 m^3/min and leaves the turbine at 500°C. Using variable specific heats for air and assuming a compressor isentropic efficiency of 82 percent and a turbine isentropic efficiency of 88 percent, determine (a) the net power output, (b) the back work ratio, and (c) the thermal efficiency.
Answers: (a) 659 kW, (b) 0.625, (c) 0.319

Q4. An ideal Brayton cycle with regeneration has a pressure ratio of 10. Air enters the compressor at 300 K and the turbine at 1200 K. If the effectiveness of the regenerator is 100 percent, determine the net work output and the thermal efficiency of the cycle.

Q5. A Brayton cycle with regeneration using air as the working fluid has a pressure ratio of 7. The minimum and maximum temperatures in the cycle are 310 and 1150 K. Assuming an isentropic efficiency of 75 percent for the compressor and 82 percent for the turbine and an effectiveness of 65 percent for the regenerator, determine (a) the air temperature at the turbine exit, (b) the net work output, and (c) the thermal efficiency.
Answers: (a) 783 K, (b) 108.1 kJ/kg, (c) 22.5 percent

Q6. Consider an ideal gas-turbine cycle with two stages of compression and two stages of expansion. The pressure ratio across each stage of the compressor and turbine is 3. The air enters each stage of the compressor at 300 K and each stage of the turbine at 1200 K. Determine the back work ratio and the

thermal efficiency of the cycle, assuming (a) no regenerator is used and (b) a regenerator with 75 percent effectiveness is used.

Q7. Repeat Q6, assuming an efficiency of 80 percent for each compressor stage and an efficiency of 85 percent for each turbine stage.

Section 2: Refrigeration Cycles

Q1. A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.12 and 0.7 MPa. The mass flow rate of the refrigerant is 0.05 kg/s. Show the cycle on a T-s diagram with respect to saturation lines. Determine (a) the rate of heat removal from the refrigerated space and the power input to the compressor, (b) the rate of heat rejection to the environment, and (c) the coefficient of performance.
Answers: (a) 7.41 kW, 1.83 kW, (b) 9.23 kW, (c) 4.06

Q2. A commercial refrigerator with refrigerant-134a as the working fluid is used to keep the refrigerated space at -30°C by rejecting its waste heat to cooling water that enters the condenser at 18°C at a rate of 0.25 kg/s and leaves at 26°C. The refrigerant enters the condenser at 1.2 MPa and 65°C and leaves at 42°C. The inlet state of the compressor is 60 kPa and -34°C and the compressor is estimated to gain a net heat of 450 W from the surroundings. Determine (a) the quality of the refrigerant at the evaporator inlet, (b) the refrigeration load, (c) the COP of the refrigerator, and (d) the theoretical maximum refrigeration load for the same power input to the compressor.

Q3. A gas refrigeration system using air as the working fluid has a pressure ratio of 4. Air enters the compressor at -7°C. The high-pressure air is cooled to 27°C by rejecting heat to the surroundings. It is further cooled to -15°C by regenerative cooling before it enters the turbine. Assuming both the turbine and the compressor to be isentropic and using constant specific heats at room temperature, determine (a) the lowest temperature that can be obtained by this cycle, (b) the coefficient of performance of the cycle, and (c) the mass flow rate of air for a refrigeration rate of 12 kW.
Answers: (a) -99.4°C, (b) 1.12, (c) 0.237 kg/s

Q4. A gas refrigeration system using air as the working fluid has a pressure ratio of 5. Air enters the compressor at 0°C. The high-pressure air is cooled to 35°C by rejecting heat to the surroundings. The refrigerant leaves the turbine at -80°C and then it absorbs heat from the refrigerated space before entering the regenerator. The mass flow rate of air is 0.4 kg/s. Assuming isentropic efficiencies of 80 percent for the compressor and 85 percent for the turbine and using constant specific heats at room temperature, determine (a) the effectiveness of the regenerator, (b) the rate of heat removal from the refrigerated space, and (c) the COP of the cycle. Also, determine (d) the refrigeration load and the COP if this system operated on the simple gas refrigeration cycle. Use the same compressor inlet temperature

as given, the same turbine inlet temperature as calculated, and the same compressor and turbine efficiencies.

Answers: (a) 0.434, (b) 21.4 kW, (c) 0.478, (d) 24.7 kW, 0.599

Q5. An absorption refrigeration system receives heat from a source at 120°C and maintains the refrigerated space at 0°C. If the temperature of the environment is 25°C, what is the maximum COP this absorption refrigeration system can have?

Q6. An absorption air-conditioning system is to remove heat from the conditioned space at 20°C at a rate of 150 kJ/s while operating in an environment at 35°C. Heat is to be supplied from a geothermal source at 140°C. What is the minimum rate of heat supply ?