

### Assignment

- 1) An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression process, air is at 100 kPa and 17°C, and 800 kJ/kg of heat is transferred to air during the constant-volume heat-addition process. Accounting for the variation of specific heats of air with temperature, determine (a) the maximum temperature and pressure that occur during the cycle, (b) the net work output, (c) the thermal efficiency, and (d) the mean effective pressure for the cycle.
- 2) An air-standard Diesel cycle has a compression ratio of 16 and a cutoff ratio of 2. At the beginning of the compression process, air is at 95 kPa and 27°C. Accounting for the variation of specific heats with temperature, determine (a) the temperature after the heat-addition process, (b) the thermal efficiency, and (c) the mean effective pressure.
- 3) A gas-turbine power plant operating on an ideal Brayton cycle has a pressure ratio of 8. The gas temperature is 300 K at the compressor inlet and 1300 K at the turbine inlet. Utilizing the air-standard assumptions, determine (a) the gas temperature at the exits of the compressor and the turbine, (b) the back work ratio, and (c) the thermal efficiency.
- 4) Consider a steam power plant operating on the simple ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the condenser at a pressure of 75 kPa. Determine the thermal efficiency of this cycle.
- 5) Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the condenser at a pressure of 10 kPa. Determine (a) the thermal efficiency of this power plant, (b) the thermal efficiency if steam is superheated to 600°C instead of 350°C, and (c) the thermal efficiency if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 600°C.
- 6) Consider a steam power plant operating on the ideal reheat Rankine cycle. Steam enters the high-pressure turbine at 15 MPa and 600°C and is condensed in the condenser at a pressure of 10 kPa. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 10.4 percent, determine (a) the pressure at which the steam should be reheated and (b) the thermal efficiency of the cycle. Assume the steam is reheated to the inlet temperature of the high-pressure turbine.
- 7) Consider a steam power plant that operates on a simple ideal Rankine cycle and has a net power output of 45 MW. Steam enters the turbine at 7 MPa and 500°C and is cooled in the condenser at a pressure of 10 kPa by running cooling water from a lake through the tubes of the condenser
- 8) at a rate of 2000 kg/s. Show the cycle on a T-s diagram with respect to saturation lines, and determine (a) the thermal efficiency of the cycle, (b) the mass flow rate of the steam, and (c) the temperature rise of the cooling water.
- 9) A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.14 and 0.8 MPa. If the mass flow rate of the refrigerant is 0.05 kg/s, 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 COP of the refrigerator.

- 10) Consider a two-stage cascade refrigeration system operating between the pressure limits of 0.8 and 0.14 MPa. Each stage operates on an ideal vapor compression refrigeration cycle with refrigerant-134a as the working fluid. Heat rejection from the lower cycle to the upper cycle takes place in an adiabatic counterflow heat exchanger where both streams enter at about 0.32 MPa. If the mass flow rate of the refrigerant through the upper cycle is 0.05 kg/s, determine (a) the mass flow rate of the refrigerant through the lower cycle, (b) the rate of heat removal from the refrigerated space and the power input to the compressor, and (c) the coefficient of performance of this cascade refrigerator.
- 11) A 5-m  $\times$  5-m  $\times$  3-m room contains air at 25°C and 100 kPa at a relative humidity of 75 percent. Determine (a) the partial pressure of dry air, (b) the specific humidity, (c) the enthalpy per unit mass of the dry air, and (d) the masses of the dry air and water vapor in the room.
- 12) The air in a room has a pressure of 1 atm, a dry-bulb temperature of 24°C, and a wet-bulb temperature of 17°C. Using the psychrometric chart, determine (a) the specific humidity, (b) the enthalpy (in kJ/kg dry air), (c) the relative humidity, (d) the dew-point temperature, and (e) the specific volume of the air (in m<sup>3</sup>/kg dry air).
- 13) One kmol of octane (C<sub>8</sub>H<sub>18</sub>) is burned with air that contains 20 kmol of O<sub>2</sub>. Assuming the products contain only CO<sub>2</sub>, H<sub>2</sub>O, O<sub>2</sub>, and N<sub>2</sub>, determine the mole number of each gas in the products and the air–fuel ratio for this combustion process.
- 14) Ethane (C<sub>2</sub>H<sub>6</sub>) is burned with 20 percent excess air during a combustion process. Assuming complete combustion and a total pressure of 100 kPa, determine (a) the air–fuel ratio and (b) the dew-point temperature of the products.
- 15) A certain natural gas has the following volumetric analysis: 72 percent CH<sub>4</sub>, 9 percent H<sub>2</sub>, 14 percent N<sub>2</sub>, 2 percent O<sub>2</sub>, and 3 percent CO<sub>2</sub>. This gas is now burned with the stoichiometric amount of air that enters the combustion chamber at 20°C, 1 atm, and 80 percent relative humidity. Assuming complete combustion and a total pressure of 1 atm, determine the dew-point temperature of the products.
- 16) Determine the enthalpy of combustion of liquid octane (C<sub>8</sub>H<sub>18</sub>) at 25°C and 1 atm, using enthalpy-of-formation data. Assume the water in the products is in the liquid form.
- 17) Propane (C<sub>3</sub>H<sub>8</sub>) is burned with 75 percent excess air during a combustion process. Assuming complete combustion, determine the air–fuel ratio.
- 18) Propyl alcohol (C<sub>3</sub>H<sub>7</sub>OH) is burned with 50 percent excess air. Write the balanced reaction equation for complete combustion and determine the air-to-fuel ratio.