Tutorial-V
(Thermodynamic Cycles)
(not to be submitted)

Assume air to be ideal gas with molar mass of ***29 g****, specific gas constant of* ***0.287 kJ/kg.K****,* $Cv =$ ***0.718 kJ/kg.K*** *and* $Cp =$ ***1.005 kJ/kg.K****.*

1. A steam power plant operating in an ideal Rankine cycle has a high pressure of 5 MPa and a low pressure of 15 kPa. The turbine exhaust state should have a quality of at least 95%, and the turbine power generated should be 7.5 MW. Find the necessary boiler exit temperature and the total mass flow rate.

2. A smaller power plant produces 25 kg/s steam at 3 MPa, 600°C, in the boiler. After expansion in high-pressure turbine, reheat is done at 500 kPa up to only 400°C and then expansion takes place in the low-pressure turbine. Low pressure turbine exit steam is cooled such that the condenser exit is saturated liquid at 45°C. Find the net power output and the total heat transfer in the boiler.

3. Consider the reverse Rankine based refrigeration cycle that has a condenser outlet temperature of 45°C and quality=0 whereas the evaporator exit temperature of −15°C and quality = 1. Determine the COP of this refrigerator for the working fluids R-134a and R-410a assuming isentropic compression process.

4. A large stationary Brayton-cycle gas turbine power plant delivers a power output of 100MW to an electric generator. The minimum temperature in the cycle is 300 K, and the maximum temperature is 1600 K. The minimum pressure in the cycle is 100 kPa, and the compressor pressure ratio is 14 to 1. Calculate the power output of the turbine. What is the back work ratio (%) for this cycle? What is the thermal efficiency of the cycle (%)?

5. A four-stroke petrol engine has a net displacement volume (= difference between volume of cylinder at BDC and TDC) is 2.4 L and a compression ratio of 10:1. The air temperature and pressure at the start of compression process is at 290 K & 75 kPa respectively. The "mean effective pressure" of this cycle is 600 kPa. Find the cycle efficiency (%) and specific power output of this cycle (kJ/kg).

6. For a diesel engine air at the start of compression stroke is at 95 kPa and 300 K. The compression ratio of this engine is 20:1. The combustion releases 1300 kJ/kg. Find the temperature after combustion (K), cycle efficiency (%) and mean effective pressure (kPa).

ANSWER KEY

1. 760°C, 4.82 kg/s
2. 34.82 MW, 91.7 MW
3. 3.07, 2.87
4. 166.32 MW, 40%, 53%
5. 60%, 600 kJ/kg
6. 2290 K, 63.4%, 957 kPa