Course : Applied Thermal Engineering (UMT303)

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

Tutorial No. 09 **Topic: Gas Power Cycle**

Q1. Air enters the compressor of an ideal air-standard Brayton cycle at 100 kPa, 300 K, with a volumetric flow rate of 5 m3/s. The compressor pressure ratio is 10. The turbine inlet temperature is 1400 K. Determine
(a) the thermal efficiency of the cycle,
(b) the back work ratio,
(c) the net power developed, in kW.

[Ans. 45.7%, 39.6%, 2481kW]

Q2. Consider a modification of the cycle of **Q1** that turbine and compressor each have an isentropic efficiency of 80%. Determine for the modified cycle
(a) the thermal efficiency of the cycle,
(b) the back workratio,
(c) the net power developed, in kW

[Ans. 24.9%, 61.8%, 1254kW]

Q3. Consider a modification of the cycle of **Q1** involving reheat and regeneration. The expansion takes place isentropically in two stages, with reheat to 1400 K between the stages at a constant pressure of 300 kPa. A regenerator having an effectiveness of 100% is also incorporated in the cycle. Determine the thermal efficiency. **[Ans. 65.4%]**

Q4. 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. **[Ans. 540K, 770K, 40.3%, 42.6%]**

Q5. Air is compressed from 100 kPa, 300 K to 1000 kPa in a two-stage compressor with intercooling between stages. The intercooler pressure is 300 kPa. The air is cooled back to 300 K in the intercooler before entering the second compressor stage. Each compressor stage is isentropic. For steady-state operation and negligible changes in kinetic and potential energy from inlet to exit, determine
(a) the temperature at the exit of the second compressor stage and
(b) the total compressor work input per unit of mass flow.
(c) Repeat for a single stage of compression from the given inlet state to the final pressure.

[**Ans. 422K, 234.7kJ/kg, 279.7kJ/kg]**

Q6. An ideal gas-turbine cycle with two stages of compression and two stages of expansion has an overall pressure ratio of 8. Air enters each stage of the compressor at 300 K and each stage of the turbine at 1300 K. Determine the back work ratio and the thermal efficiency of this gas-turbine cycle, assuming

(a) no regenerators and
(b) an ideal regenerator with 100% effectiveness.

[Ans. 30.4%, 35.8%, 30.4%, 69.6%]

Q7. A combined gas turbine–vapor power plant has a net power output of 45 MW. Air enters the compressor of the gas turbine at 100 kPa, 300 K, and is compressed to 1200 kPa. The isentropic efficiency of the compressor is 84%. The condition at the inlet to the turbine is 1200 kPa, 1400 K. Air expands through the turbine, which has an isentropic efficiency of 88%, to a pressure of 100 kPa. The air then passes through the interconnecting heatrecovery steam generator and is finally discharged at 400 K. Steam enters the turbine of the vapor power cycle at 8 MPa, 400^{o}C, and expands to the condenser pressure of 8 kPa. Water enters the pump as saturated liquid at 8 kPa. The turbine and pump of the vapor cycle have isentropic efficiencies of 90 and 80%, respectively. Determine
(a) the mass flow rates of the air and the steam, each in kg/s;
(b) the net power developed by the gas turbine and vapor power cycle, each in MW; and
(c) the thermal efficiency.

[Ans. 100.87kg/s, 15.6kg/s, 29.03MW, 15.97MW, 52.8%]