Course : Applied Thermal Engineering (UMT303)

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

Tutorial No. 08 **Topic: Vapor Power cycle**

Q1. A steam power plant operates on the Rankine cycle. If the isentropic efficiency of the turbine is 87%and the isentropic efficiency of the pump is 85%t, determine
(a) the thermal efficiency of the cycle and
(b) the net power output of the plant for a mass flow rate of 15 kg/s.

[Ans. 36.1%, 18.9MW]

Q2. 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 **[Ans. 33.4%, 37.3%, 43%]**

Q3. 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. **[Ans. 40bar, 45%]**

Q4. Consider a steam power plant operating on the ideal regenerative Rankine cycle with one open feedwater heater. Steam enters the turbine at 15 MPa and 600°C and is condensed in the condenser at a pressure of 10 kPa. Some steam leaves the turbine at a pressure of 1.2 MPa and enters the open feedwater heater. Determine the fraction of steam extracted from the turbine and the thermal efficiency of the cycle. **[Ans. 0.227, 46.3%]**

Q5. Consider a steam power plant that operates on an ideal reheat–regenerative Rankine cycle with one open feedwater heater, one closed feedwater heater, and one reheater. Steam enters the turbine at 15 MPa and 600°C and is condensed in the condenser at a pressure of 10 kPa. Some steam is extracted from the turbine at 4 MPa for the closed feedwater heater, and the remaining steam is reheated at the same pressure to 600°C. The extracted steam is completely condensed in the heater and is pumped to 15 MPa before it mixes with the feedwater at the same pressure. Steam for the open feedwater heater is extracted from the low-pressure turbine at a pressure of 0.5 MPa. Determine the fractions of steam extracted from the turbine as well as the thermal efficiency of the cycle. **[Ans. 0.1766, 0.1306, 49.2%]**

Q6. Consider the cogeneration plant. Steam enters the turbine at 7 MPa and 500°C. Some steam is extracted from the turbine at 500 kPa for process heating. The remaining steam continues to expand to 5 kPa. Steam is then condensed at constant pressure and pumped to the boiler pressure of 7 MPa. At times of high demand for process heat, some steam leaving the boiler is throttled to 500 kPa and is routed to the process heater. The extraction fractions are adjusted so that steam leaves the process heater as a saturated liquid at 500 kPa. It is subsequently pumped to 7 MPa. The mass flow rate of steam through the boiler is 15 kg/s.

Disregarding any pressure drops and heat losses in the piping and assuming the turbine and the pump to be isentropic, determine

(a) the maximum rate at which process heat can be supplied,

(b) the power produced and the utilization factor when no process heat is supplied, and

(c) the rate of process heat supply when 10%of the steam is extracted before it enters the turbine and 70%of the steam is extracted from the turbine at 500 kPa for process heating.

[Ans. 41.57MW, 20MW, 40.8%]

Q7. Consider the combined gas–steam power cycle. The topping cycle is a gas-turbine cycle that has a pressure ratio of 8. Air enters the compressor at 300 K and the turbine at 1300 K. The isentropic efficiency of the compressor is 80%, and that of the gas turbine is 85%. The bottoming cycle is a simple ideal Rankine cycle operating between the pressure limits of 7 MPa and 5 kPa. Steam is heated in a heat exchanger by the exhaust gases to a temperature of 500°C. The exhaust gases leave the heat exchanger at 450 K. Determine

(a) the ratio of the mass flow rates of the steam and the combustion gases and

(b) the thermal efficiency of the combined cycle.

[Ans. 0.131, 48.7%]