
Course Name: Engineering Thermodynamics

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Solved Problems on Vapor Power Cycles

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Q#1. Consider a steam power plant operating on the Rankine cycle. Steam enters the turbine at 3MPa and 350°C, and is condensed in the condenser at a pressure of 75kpa. Determine the thermal efficiency of this cycle.

Q#2. Consider a 210-MW steam power plant that operates on a simple ideal Rankine cycle. Steam enters the turbine at 10 MPa and 500°C and is cooled in the condenser at a pressure of 10kpa. Show the cycle on a T-s diagram with respect to saturation lines, and determine **(a)** the quality of the steam at the turbine exit, **(b)** the thermal efficiency of the cycle, and **(c)** the mass flow rate of the steam.

Q#3. A steam power plant operates on a simple ideal Rankine cycle between the pressure limits of 3 MPa and 50kpa. The temperature of the steam at the turbine inlet is 300°C, and the mass flow rate of steam through the cycle is 35 kg/s. Show the cycle on a T-s diagram with respect to saturation lines, and determine **(a)** the thermal efficiency of the cycle and **(b)** the net power output of the power plant.

Q#4. 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 10kpa by running cooling water from a lake through the tubes of the condenser at a rate of 2000 kg/s with specific heat for cooling water is 4.184kJ/k. the isentropic efficiency for both turbine and compressor are 87percent. 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.

Q#5. 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 10kpa. 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.

Q#6. A steam power plant operates on an ideal Rankine cycle with two stages of reheat and has a net power output of 75 MW. Steam enters all three stages of the turbine at 550°C. The maximum pressure in the cycle is 10 MPa, and the minimum pressure is 30 kPa. Steam is reheated at 4 MPa the first time and at 2 MPa the second time. Show the cycle on a T-s diagram with respect to saturation lines, and determine **(a)** the thermal efficiency of the cycle and **(b)** the mass flow rate of the steam.

Q#7. A steam power plant operates on an ideal reheat Rankine cycle between the pressure limits of 15 MPa and 10kpa. The mass flow rate of steam through the cycle is 12 kg/s. Steam enters both stages of the turbine at 500°C. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 10 percent, determine **(a)** the pressure at which reheating takes place, **(b)** the total rate of heat input in the boiler, and **(c)** the thermal efficiency of the cycle. Also, show the cycle on a T-s diagram with respect to saturation lines.

Q#8. A steam power plant operates on the reheat Rankine cycle. Steam enters the high-pressure turbine at 12.5 MPa and 550°C at a rate of 7.7 kg/s and leaves at 2 MPa. Steam is then reheated at constant pressure to 450°C before it expands in the low-pressure turbine. The isentropic efficiencies of the turbine and the pump are 85 percent and 90 percent, respectively. Steam leaves the condenser as a saturated liquid. If the moisture content of the steam at the exit of the turbine is not to exceed 5 percent, determine **(a)** the condenser pressure, **(b)** the net power output, and **(c)** the thermal efficiency

Q#9. Consider a steam power plant that operates on a reheat Rankine cycle and has a net power output of 80 MW. Steam enters the high-pressure turbine at 10 MPa and 500°C and the low-pressure turbine at 1 MPa and 500°C. Steam leaves the condenser as a saturated liquid at a pressure of 10kpa. The isentropic efficiency of the turbine is 80 percent, and that of the pump is 95 percent. Show the cycle on a T-s diagram with respect to saturation lines, and determine **(a)** the quality (or temperature, if superheated) of the steam at the turbine exit, **(b)** the thermal efficiency of the cycle, and **(c)** the mass flow rate of the steam.

Q#10. Steam is the working fluid in an ideal Rankine cycle with superheat and reheat. Steam enters the first-stage turbine at 8.0 MPa, 480C, and expands to 0.7 MPa. It is then reheated to 440C before entering the second-stage turbine, where it expands to the condenser pressure of 75kpa. The net power output is 100 MW. Determine **(a)** the thermal efficiency of the cycle, **(b)** the mass flow rate of steam, in kg/h, and **(c)** the rate of heat transfer from the condensing steam as it passes through the condenser, in MW.

Q#11. A steam power plant operates on an ideal regenerative Rankine cycle. Steam enters the turbine at 6 MPa and 450°C and is condensed in the condenser at 20kpa. Steam is extracted from the turbine at 0.4 MPa to heat the feed water in an open feed water heater. Water leaves the feed water heater as a saturated liquid. Show the cycle on a T-s diagram, and determine **(a)** the network output per kilogram of steam flowing through the boiler and **(b)** the thermal efficiency of the cycle.

Q#12. A steam power plant operates on an ideal regenerative Rankine cycle with two open feed water heaters. Steam enters the turbine at 8 MPa and 550°C and exhausts to the condenser at 15 kPa. Steam is extracted from the turbine at 0.6 and 0.2 MPa. Water leaves both feed water heaters as a saturated liquid. The mass flow rate of steam through the boiler is 24 kg/s. Show the cycle on a T-s diagram, and determine **(a)** the net power output of the power plant and **(b)** the thermal efficiency of the cycle