Aalto University

Thermodynamics and Heat Transfer

Learning Exercises 4: Part 1- 50 Points

Lecture 7: Vapor and Combined Power Cycles

Problem 1: A supply of geothermal hot water is used as the energy source in an ideal Rankine cycle with R-134a, as shown in Fig. 1. Saturated vapor R-134a leaves the boiler at a temperature of 85 ℃, and the condenser temperature is 40 ℃. Calculate the thermal efficiency of this cycle. Compare your results with NH_3 as working fluid (15 points).

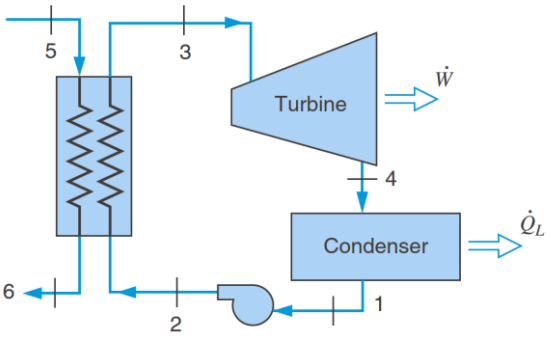

Figure 1

Problem 2: A utility runs a Rankine cycle with a water boiler at 3.0 MPa, and the cycle has the highest and lowest temperatures of 450◦C and 60◦C, respectively. Find the plant efficiency and the efficiency of a Carnot cycle with the same temperatures (10 points).

Problem 3: Consider the ammonia Rankine-cycle power plant shown in Fig. 2. The plant was designed to operate in a location where the ocean water temperature is 25℃ near the surface and 5℃ at some greater depth. The mass flow rate of the working fluid is 1000 kg/s (15 points).

a. Determine the turbine power output and the pump power input for the cycle.

b. Determine the mass flow rate of ocean water through each heat exchanger.

c. What is the thermal efficiency of this power plant?

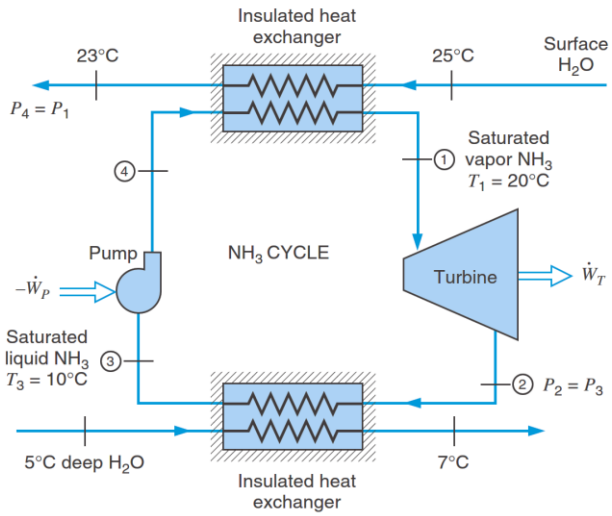

Figure 2

Problem 4: A small power plant produces steam at 3 MPa, 600 ℃ in the boiler. It keeps the condenser at 45℃ by transfer of 10 MW out as heat transfer. The first turbine section expands to 500 kPa, and then flow is reheated followed by expansion in the low-pressure turbine. Find the reheat temperature so that the turbine output is saturated vapor. For this reheat, find the total turbine power output and the boiler heat transfer (10 points).