Problem 1

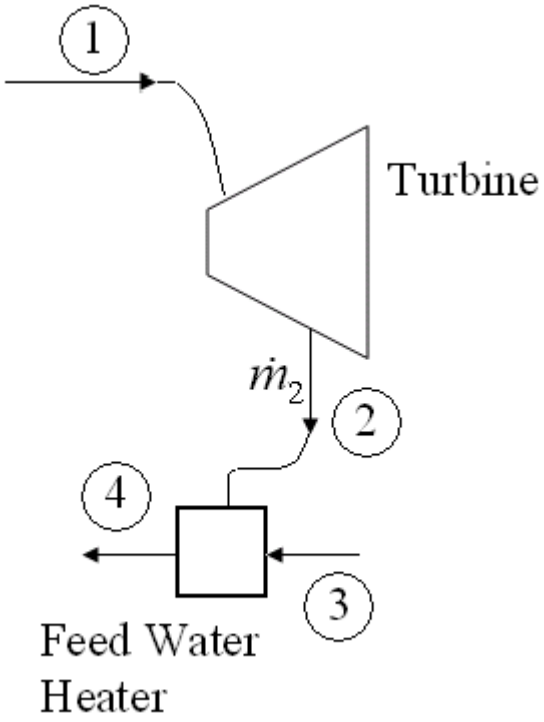
A steam-driven electrical generator provides 8.1MW of electrical power at a rated efficiency of 90%. The steam turbine driving the generator has been designed to operate at a mass flow rate of 17kg/s and an inlet pressure and temperature of 3MPa and 450°C respectively. The inlet velocity to the turbine is 200m/s. The turbine exhausts saturated vapor at 0.5MPa at an exit velocity of 80m/s. The operating temperature of the turbine is maintained using a oil coolant system with a mass flow of oil of 5kg/s. Calculate the final temperature of the coolant oil if the initial oil temperature is 50°C. The specific heat of the oil is 1.9kJ/kg-K.

Hint: Assume that all the heat loss from the turbine system is to oil coolant stream.

Problem 2

The turbine and the feed water heater of an idealized Rankine cycle with one open feed water heater are shown in the figure. Steam enters the isentropic turbine at 640°C temperature and 8 MPa pressure, at a flow rate of 55 kg/s. The feed water heater pressure is 500 kPa, and the fluid enters at 45°C temperature and exits from the feed water heater as a saturated liquid. The surroundings is at 30°C.

a) Draw the lay out and the *T-s* diagram cycle for an ideal Rankine cycle with one open feed water heater, and show points 1, 2, 3 and 4 on the cycle.
b) Find the mass flow rate of extracted vapor, $\dot{m}_2$.
c) Find the rate of exergy destruction associated with the feed water heater



Problem 3

A thermally driven heat pump is proposed. The system operates in a steady state. The heat source is high pressure liquid water (specific heat = 4.23 kJ/kg-K) flowing 10 kg/s with inlet temperature 120^{o}C and exit temperature 100^{o}C. The system is claimed to somehow heat air (Cp = 1.02 kJ/kg-K) at uniform 100 kPa from 180^{o}C to 220^{o}C flowing at 10 kg/s. The system can reject heat to ambient at 25^{o}C. These are the only interactions happening.

Question: Is this system thermodynamically possible?

Explain you answer with respect to basic thermodynamic principles and findings.