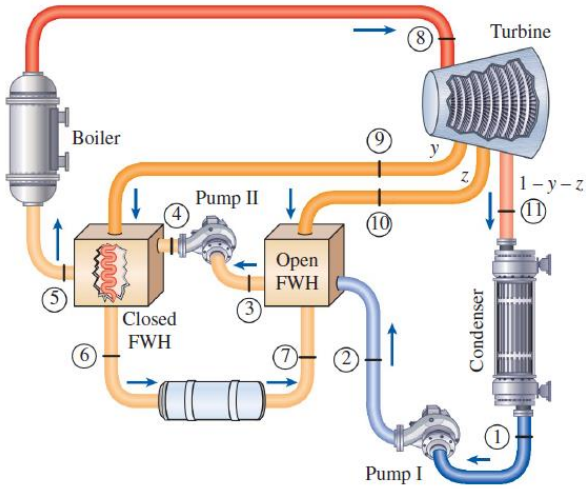
HW 4- ME442- Power plants and desalination

Questions:

Question1: Consider an ideal steam regenerative Rankine cycle with two feedwater heaters, one closed and one open. Steam enters the turbine at 10 MPa and 600C and exhausts to the condenser at 10 kPa. Steam is extracted from the turbine at 1.2 MPa for the closed feedwater heater and at 0.6 MPa for the open one. The feedwater is heated to the condensation temperature of the extracted steam in the closed feedwater heater. The extracted steam leaves the closed feedwater heater as a saturated liquid, which is subsequently throttled to the open feedwater heater.

1. Draw the cycle on a *T-s* diagram with respect to saturation lines.
2. Determine the mass flow rate of steam through the boiler for a net power output of 400 MW
3. Determine the thermal efficiency of the cycle.



Question2: A steam power plant operates on an ideal reheat–regenerative Rankine cycle and has a net power output of 80 MW. Steam enters the high-pressure turbine at 10 MPa and 550C and leaves at 0.8 MPa. Some steam is extracted at this pressure to heat the feedwater in an open feedwater heater. The rest of the steam is reheated to 500C and is expanded in the low-pressure turbine to the condenser pressure of 10 kPa.

1. Draw the reheat–regenerative steam power plant and list all components
2. Show the cycle on a T-s diagram with respect to saturation lines,
3. Determine the mass flow rate of steam through the boiler
4. Determine the thermal efficiency of the cycle.

Question3:

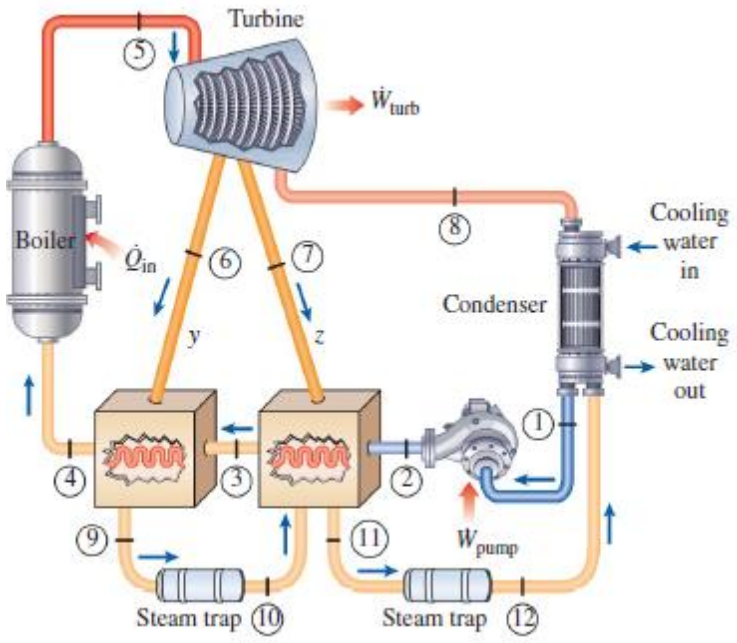
An ideal Rankine steam cycle modified with two closed feedwater heaters is shown below. The power cycle receives 75 kg/s of steam at the high pressure inlet to the turbine. The feedwater heater exit states for the boiler feedwater and the condensed steam are the normally assumed ideal states. The fraction of mass entering the high pressure turbine at state 5 that is extracted for the feedwater heater operating at 1400 kPa is y=0.1446.

1. Use the data provided in the tables given below to sketch the T-s diagram for the ideal cycle.

2. Determine the fraction of mass, z, that is extracted for the closed feedwater heater operating at the 245 kPa extraction pressure.
3. Determine the required cooling water flow rate, in kg/s, to keep the cooling water temperature rise in the condenser to 10C. Assume cp 5 4.18 kJ/kg· K for cooling water.
4. Determine the net power output and the thermal efficiency of the plant.

Process states and selected data				
State	*P*, kPa	*T*, °C	*h*, kJ/kg	*s*, kJ/kg·K
1	20			
2	5000			
3	5000			
4	5000			
5	5000	700	3900	7.512
6	1400		3406	7.512
7	245		2918	7.512
8	20		2477	7.512

Saturation data			
P, kPa	v_f, m³/kg	h_f, kJ/kg	s_g, kJ/kg·K
20	0.00102	251	7.907
245		533	7.060
1400		830	6.468
5000	0.00129	1154	5.973



MCQ Part 1:

1. Ideal 'Rankine Cycle' is a _____ process.
a) Reversible
b) Irreversible
c) Reversible & Irreversible
d) None of the mentioned

2. For analytical purposes, the Rankine Cycle is assumed to be in _____
a) Unsteady flow operation
b) Turbulent flow operation
c) Steady flow operation
d) Laminar flow operation

3. The net work done in a Rankine Cycle is the difference of _____
a) Condenser work & Boiler work
b) Boiler work & Pump work
c) Turbine Work & Pump work
d) Condenser work & Pump work

4. In a Rankine Cycle, heat input is provided to _____
a) Condenser
b) Pump
c) Turbine
d) Boiler

5. In a Rankine Cycle, heat output is obtained from _____
a) Condenser
b) Boiler
c) Turbine
d) Pump

6. The water that flows from the Pump is?
a) Compressible
b) Incompressible
c) Unsteady
d) None of the mentioned

7. Steam Rate is the reciprocal of _____
a) Net work done
b) Heat extracted from condenser
c) Heat given to reciprocal
d) Work done by turbine

8. Which of these is sometimes neglected?
a) Turbine work
b) Pump work
c) Condenser heat
d) Boiler heat

9. Efficiency of a Rankine Cycle is also expressed as _____
a) Capacity Ratio
b) Heat Rate
c) Heat Ratio
d) Steam Rate

10. Steam Power Plants are more popular in electric power generation because ____
a) Work output of turbine is very large than work input to the pump

b) Work output of turbine is very small than work input to the pump
c) Work output of turbine is equal to work input to the pump
d) None of the mentioned

12. In Rankine Cycle, water is converted to saturated liquid in _____
a) Evaporator
b) Economizer
c) Superheater
d) Preheater

14. Phase change at constant pressure takes place in _____
a) Economiser
b) Evaporator
c) Superheater
d) Air-Preheater

15. Which of these factors don't cause Internal Irreversibility of a Rankine cycle?
a) Throttling
b) Mixing
c) Fluid Friction
d) Fluid flow

MCQ Part 2:

1. What is the unit of Heat rate?
a) kJ/KW
b) KW/kJ
c) kJ
d) KW

2. Rankine cycle operating on low pressure limit of p1 and high pressure limit of p2 _
a) has higher thermal efficiency than the Carnot cycle operating between same pressure limits
b) has lower thermal efficiency than Carnot cycle operating between same pressure limits
c) has same thermal efficiency as Carnot cycle operating between same pressure limits
d) may be more or less depending upon the magnitudes of p1 and p2

3. Rankine efficiency of a Steam Power Plant _____
a) improves in Summer as compared to that in Winter
b) improves in Winter as compared to that in Summer
c) is unaffected by climatic conditions
d) none of the mentioned

4. Rankine cycle comprises of _____
a) two isentropic processes and two constant volume processes
b) two isentropic processes and two constant pressure processes
c) two isothermal processes and two constant pressure processes

d) none of the mentioned

5. In Rankine cycle, the work output from the turbine is given by _____
a) change of internal energy between inlet and outlet
b) change of enthalpy between inlet and outlet
c) change of entropy between inlet and outlet
d) change of temperature between inlet and outlet

6. Which of the following contributes to the improvement of efficiency of Rankine cycle in a Thermal Power Plant?
a) reheating of steam at intermediate stage
b) regeneration use of steam for heating Boiler feed water
c) use of high pressures
d) all of the mentioned

7. Match the following:

i) Boiler	A. reversible adiabatic expansion of steam
ii) turbine	B. constant pressure heat heat addition
iii) Condenser	C. reversible adiabatic compression
iv) pump	D. constant pressure heat rejection

a) i-B ii-A iii-D iv-C
b) i-A ii-C iii-D iv-A
c) i-B ii-D iii-C iv-A
d) i-A ii-D iii-B iv-C

8. What is the actual turbine inlet temperature in Rankine cycle?
a) 700C
b) 800C
c) 550C

9. Rankine cycle efficiency of a good Steam Power Plant may be in the range of?
a) 15 to 20%
b) 35 to 45%
c) 70 to 80%
d) 90 to 95%

10. A simple Rankine cycle operates the Boiler at 3 MPa with an outlet temperature of 350°C and the Condenser at 50 kPa. Assuming ideal operation and processes, what is the thermal efficiency of this cycle?
a) 7.7
b) 17.7
c) 27.7
d) 37.7

11. A simple Rankine cycle produces 40 MW of power, 50 MW of process heat and rejects 60 MW of heat to the surroundings. What is the utilization factor of this co generation cycle neglecting the pump work?
a) 50
b) 60

c) 70
d) 80