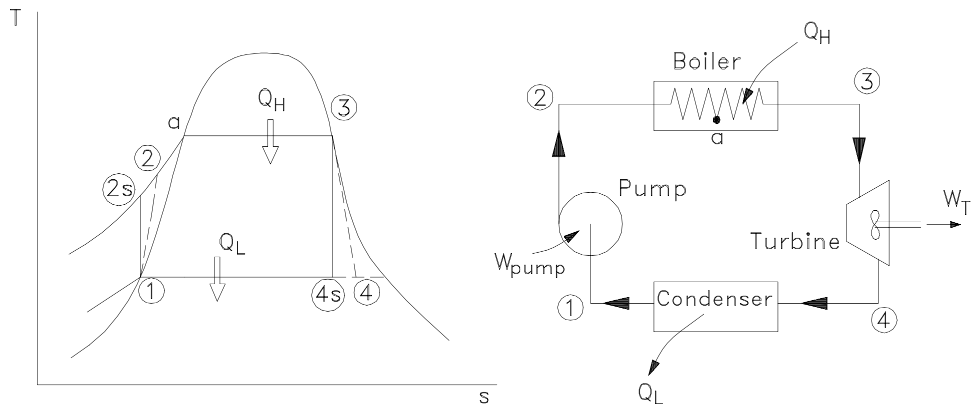
Week 4: Lecture 2

Rankine Cycle



- working fluid is alternately vaporized and condensed as it recirculates is a closed cycle
- water is typically used as the working fluid because of its low cost and relatively large value of enthalpy of vaporization
- the condensation process is allowed to proceed to completion → state point 1 - saturated liquid
- the water at state point 1 can be conveniently pumped to the boiler pressure at state point 2
- but the water is not at the saturation temperature corresponding to the boiler pressure
- heat must be added to change the water at 2 to saturated water at 'a'

Rankine Efficiency

$$
\begin{aligned}
\eta_R &= \frac{\textit{net work output}}{\textit{heat supplied in the boiler}} \\
&= \frac{(h_3 - h_4) + (h_1 - h_2)}{(h_3 - h_2)} \\
&= \frac{(h_3 - h_4) + (h_1 - h_2)}{(h_3 - h_1) + (h_1 - h_2)}
\end{aligned}
$$

If the pump work is considered negligible in relation to the turbine work i.e. $(h_1 - h_2) \to 0$

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Therefore

$$\eta_R = \frac{(h_3 - h_4)}{(h_3 - h_1)}$$

If the pump work is included and we consider the fluid to be incompressible

$$(h_1 - h_2) = v(P_1 - P_2)$$

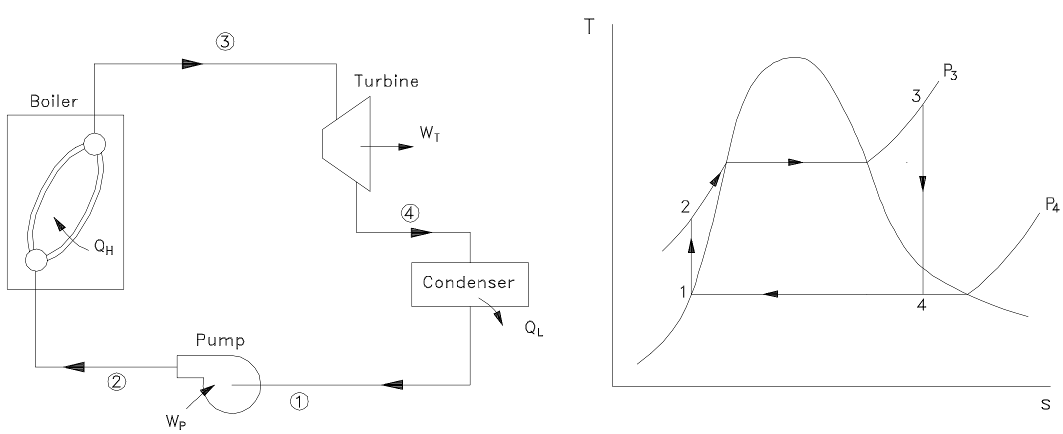
Since the actual process is irreversible, an isentropic efficiency can be defined such that

$$\text{Expansion process} \quad \Rightarrow \quad \text{Isentropic efficiency} \quad = \quad \frac{\text{actual work}}{\text{isentropic work}}$$

$$\text{Compression process} \quad \Rightarrow \quad \text{Isentropic efficiency} \quad = \quad \frac{\text{isentropic work}}{\text{actual work}}$$

Rankine Cycle with Superheat

- the average temperature at which heat is supplied in the boiler can be increased by superheating the steam
- the dry saturated steam from the boiler is passed through a second bank of smaller bore tubes within the boiler until the steam reaches the required temperature



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Rankine Cycle with Reheat

- the wetness at the exhaust of the turbine should be no greater that 10% - this can result in physical erosion of the turbine blades
- but high boiler pressures are required for high efficiency - tends to lead to a high wetness ratio
- to improve the exhaust steam conditions, the steam can be reheated with the expansion carried out in two steps