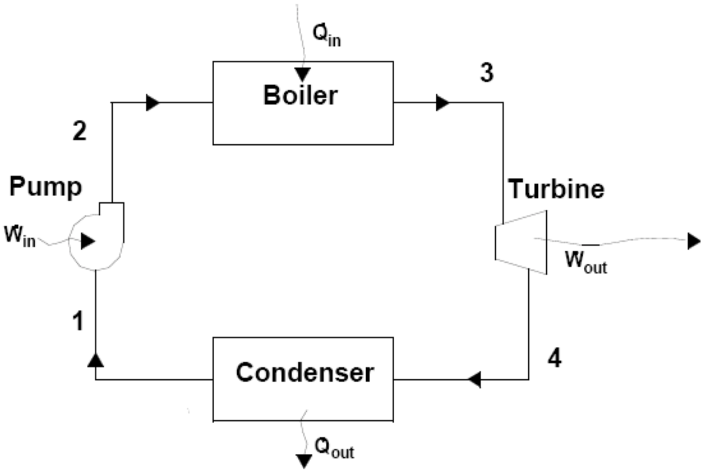
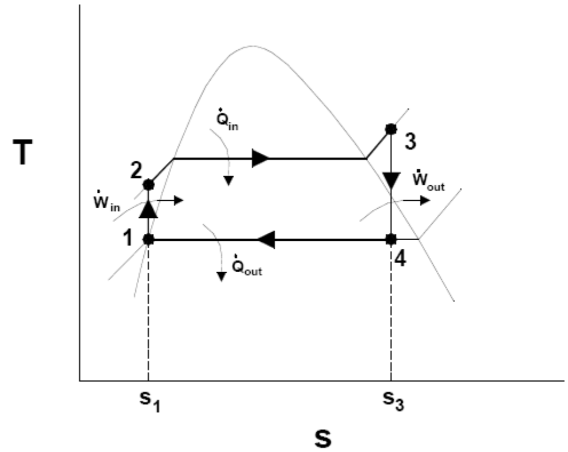
Summary

The ideal Rankine cycle schematic and T-s diagram:





Common Assumptions:

1) Boiler and Condenser are constant pressure devices (P_4=P_1 & P_3=P_2)
2) Saturated liquid at condenser outlet (state 1) & incompressible
3) Steady operating conditions
4) $\Delta ke, \Delta pe = 0$
5) For **Ideal Rankince Cycle**: Isentropic compression (s_2=s_1) & expansion (s_4=s_3)
6) The pump is a constant temperature process

Analysis:

Boiler→ $q_{in} = h_3 - h_2$

Turbine→ $w_{out} = h_3 - h_4$

Condenser→ $q_{out} = h_4 - h_1$

Pump→ $w_{in} = h_2 - h_1$

By using the definition of enthalpy $h = u + Pv$, we get by differentiation:

$$dh = du + Pdv + vdP$$

Since the fluid in the pump is incompressible, $dv = 0$ and the previous equation becomes:

$$\Delta h = \Delta u + v\Delta P$$
$$\Delta h = c_{v,avg}(\Delta T) + v\Delta P$$

With the pump being a constant temperature process, $\Delta T = 0$, and w_{in} can be expressed as:

$$w_{in} = v(P_2 - P_1)$$

Thermal Efficiency (η_{th}):

$$\eta_{th} = \frac{Benefit}{Cost} = \frac{w_{net,out}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}}$$

Isentropic Efficiencies:

Pump→ $\eta_P = \frac{w_s}{w_a} = \frac{h_{2s} - h_1}{h_{2a} - h_1}$

Turbine → $\eta_T = \frac{w_a}{w_s} = \frac{h_3 - h_{4a}}{h_3 - h_{4s}}$

<u>Question</u>

Consider a coal-fired steam power plant that produces 300MW of electric power. The power plant operates on a simple *ideal* Rankine cycle with turbine inlet conditions of 5 MPa and 450^{o}C and a condenser pressure of 25 kPa. The coal used has a heating value (energy released when the fuel is burned) of 29 300 kJ/kg. Assuming that 75% of this energy is transferred to the steam in the boiler and that the electric generator has an efficiency of 96%, determine:

a) The overall plant efficiency (the ratio of net electric power output to the energy input as fuel)
b) The required rate of coal supply