ME 266 THERMODYNAMICS 1 - Vapour Power Cycles

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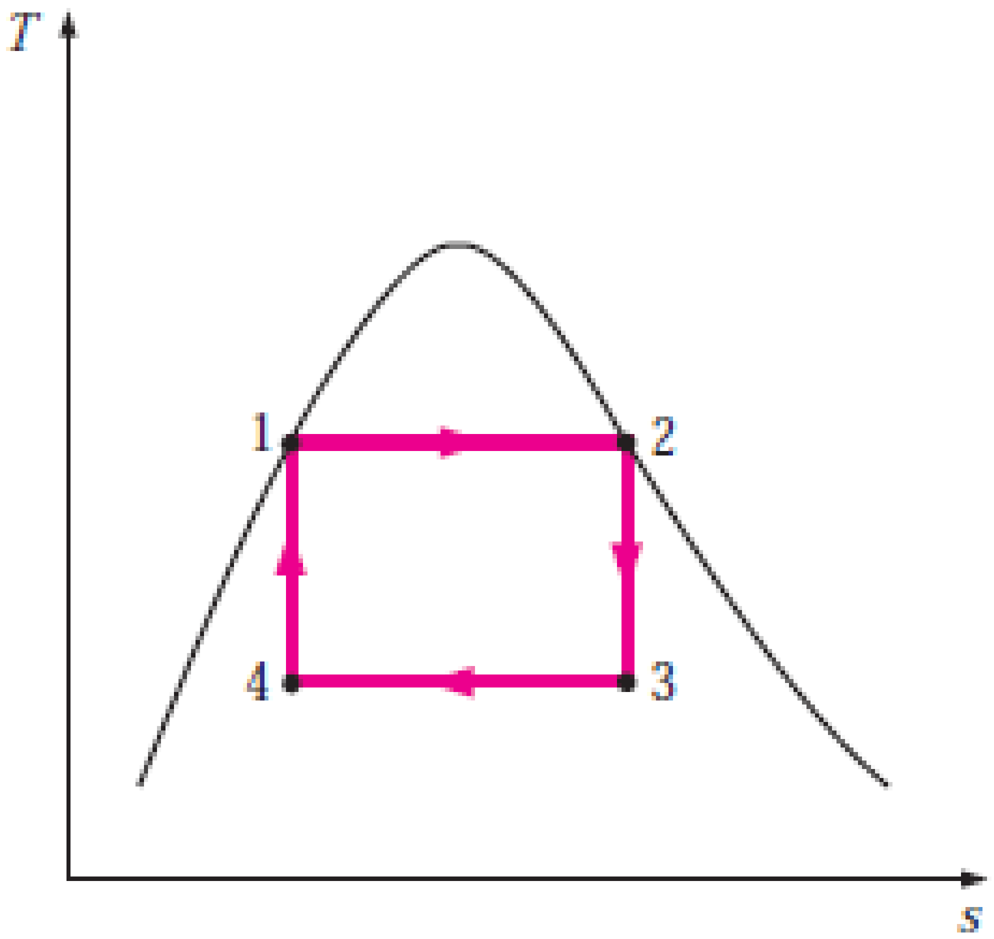
VAPOUR POWER CYCLES

Carnot vapour power cycle



1-2 Constant, T (isothermal) heat addition

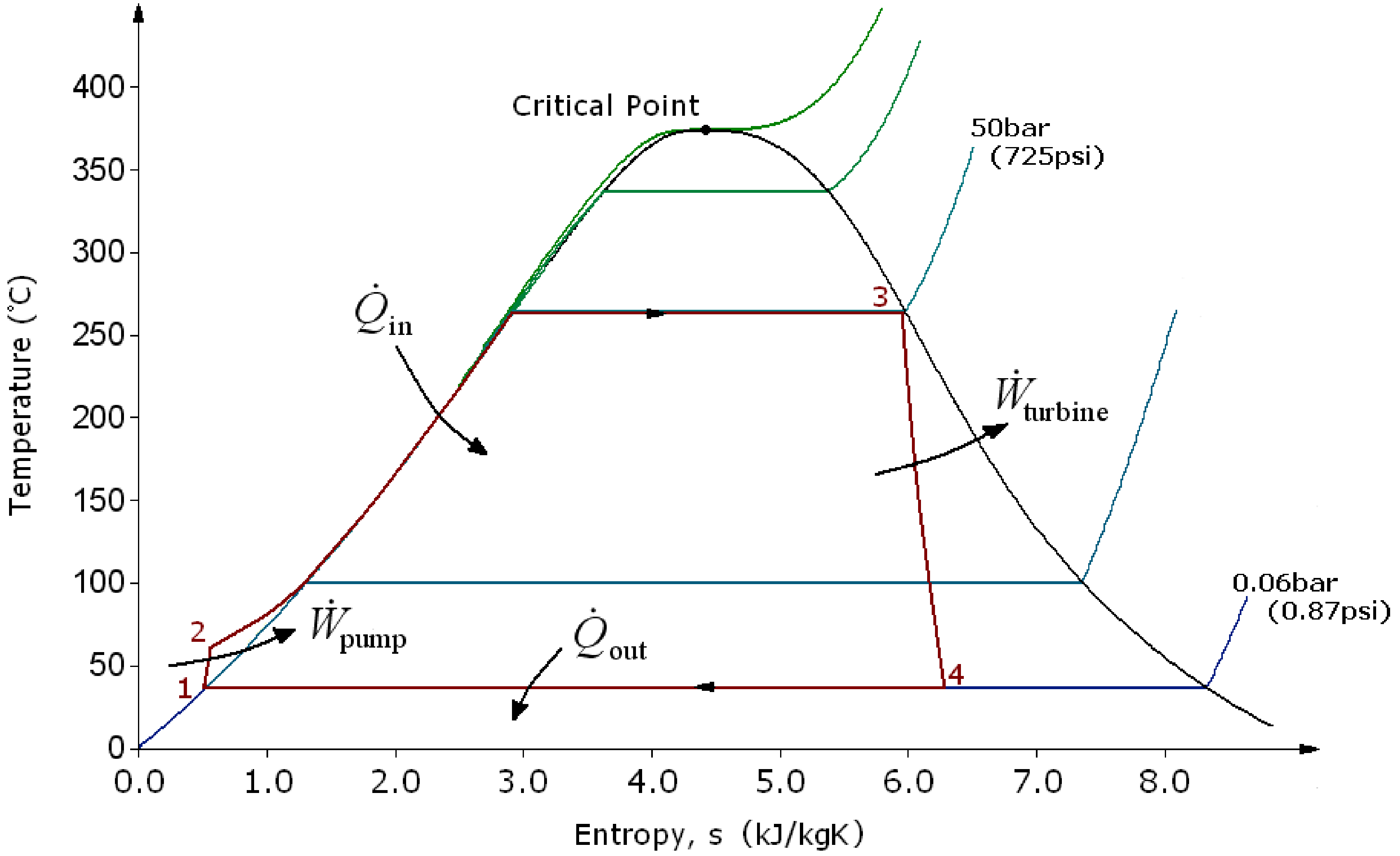
2-3 Constant entropy (isentropic)
expansion in turbine

3-4 Constant P const, T (isothermal)
heat rejection (condenser)

4-1 Constant entropy (isentropic)
compression

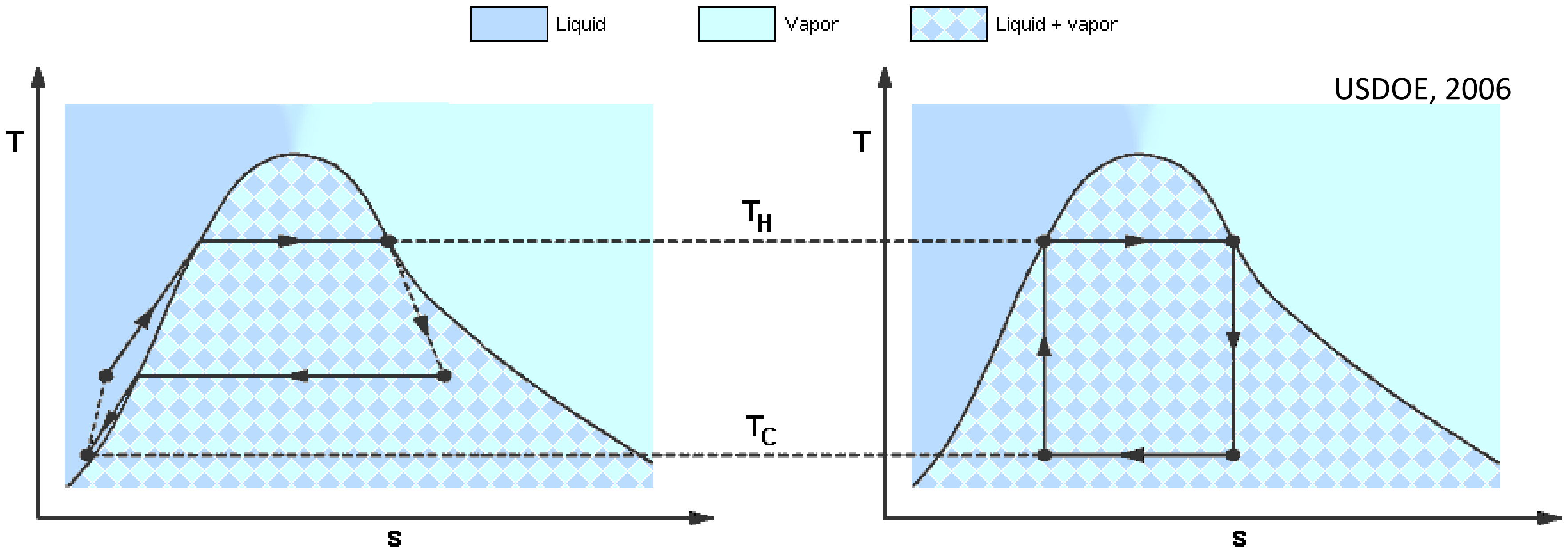
VAPOUR POWER CYCLES

Simple Rankine Cycle



VAPOR POWER CYCLES

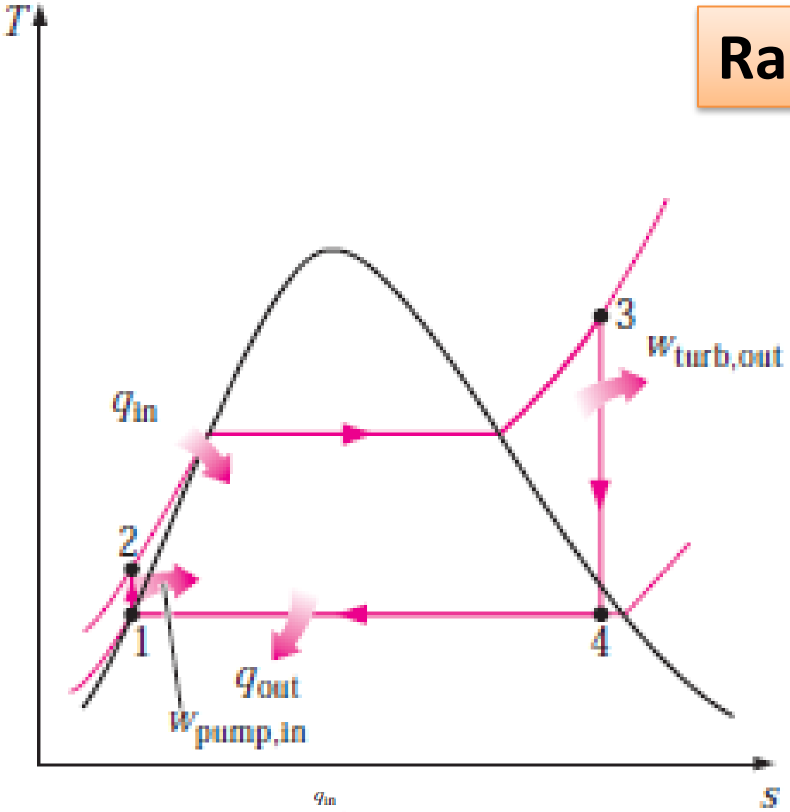
Real vs Carnot

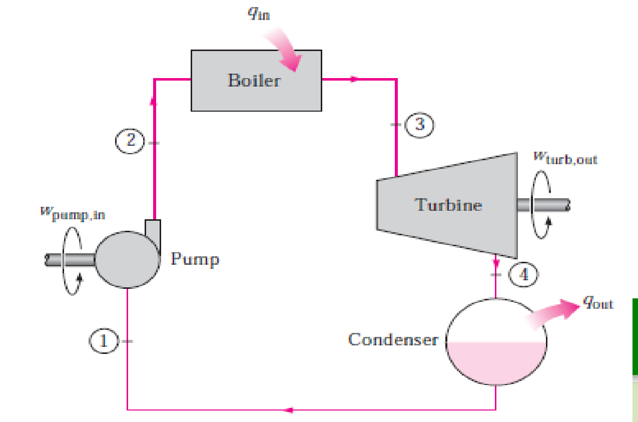


Working fluid is completely condensed and cooled.

Entropy of real processes increase.

VAPOR POWER CYCLES

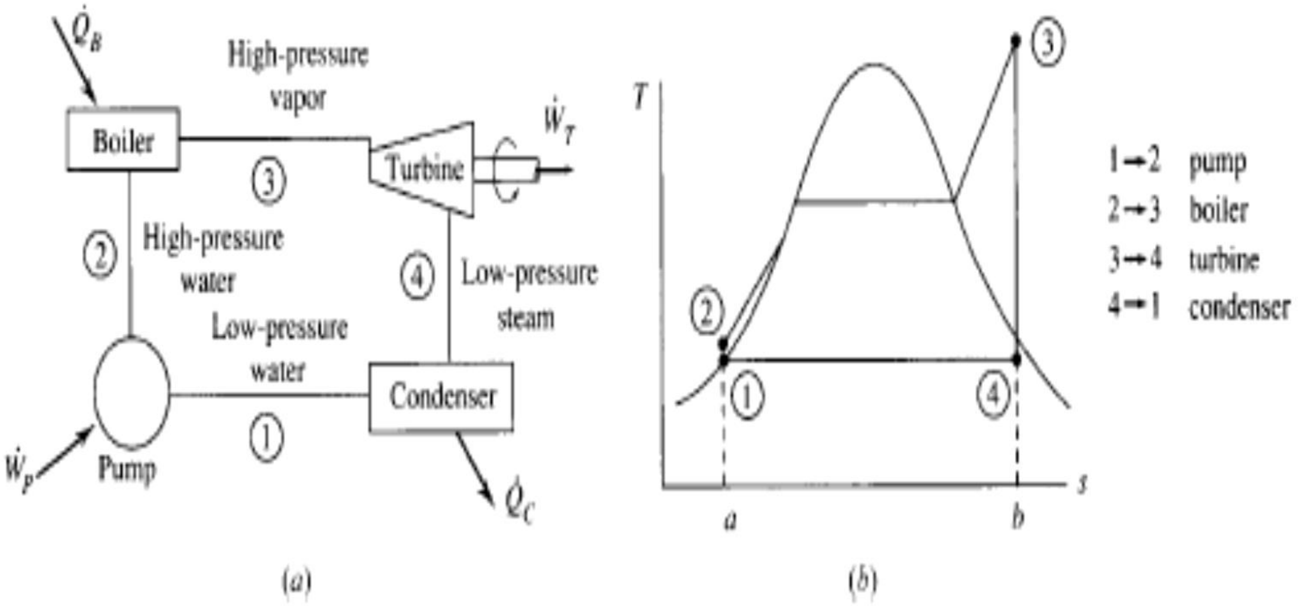




Rankine cycle with superheat

1 → 2: Isentropic compression in a pump
2 → 3: Constant-pressure heat addition in a boiler
3 → 4: Isentropic expansion in a turbine
4 → 1: Constant-pressure heat rejection in a condenser

VAPOR POWER CYCLES



$$w_p = v_1(P_2 - P_1)$$

$$q_B = h_3 - h_2$$

$$w_T = h_3 - h_4$$

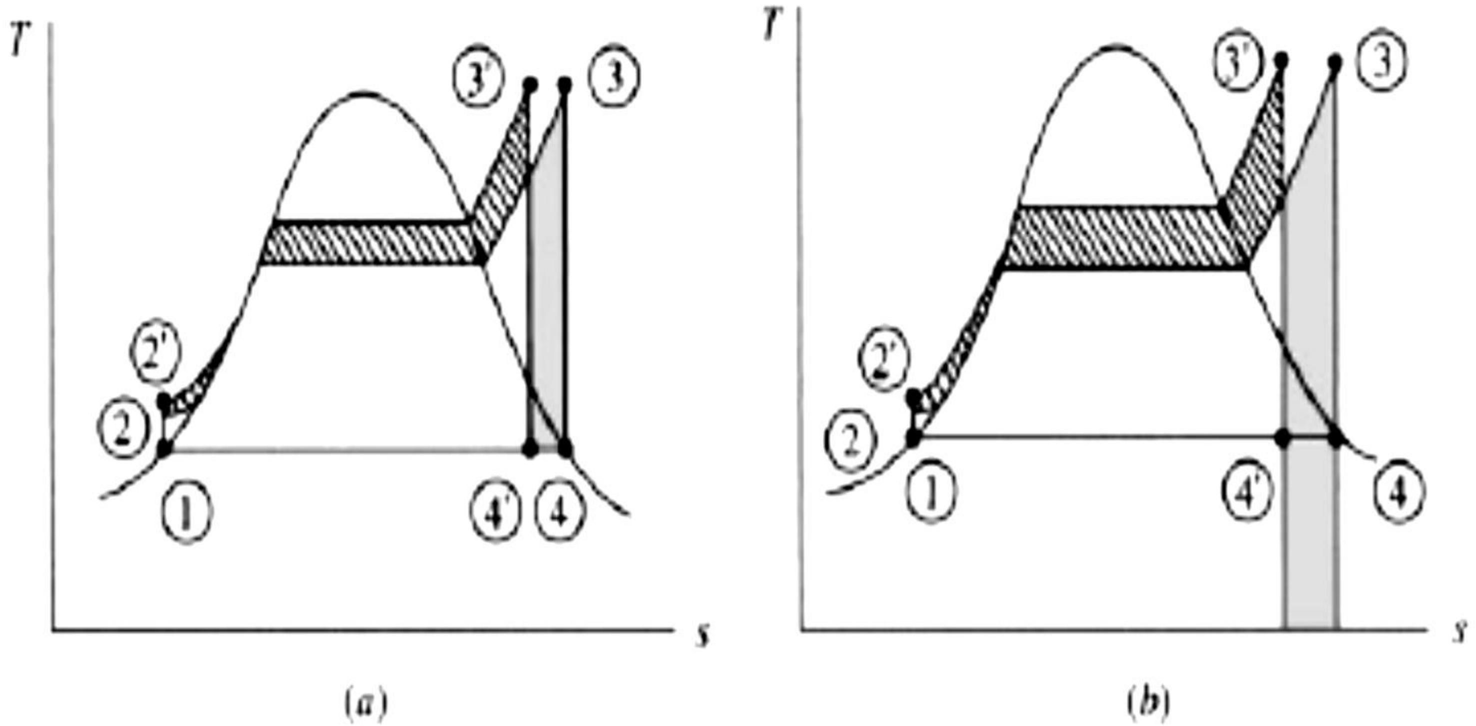
$$q_C = h_4 - h_1$$

$$\eta = \frac{w_T - w_p}{q_B}$$

$$\eta = \frac{area\ 1-2-3-4-1}{area\ a-2-3-b-a}$$

IMPROVING THE RANKINE CYCLE EFFICIENCY

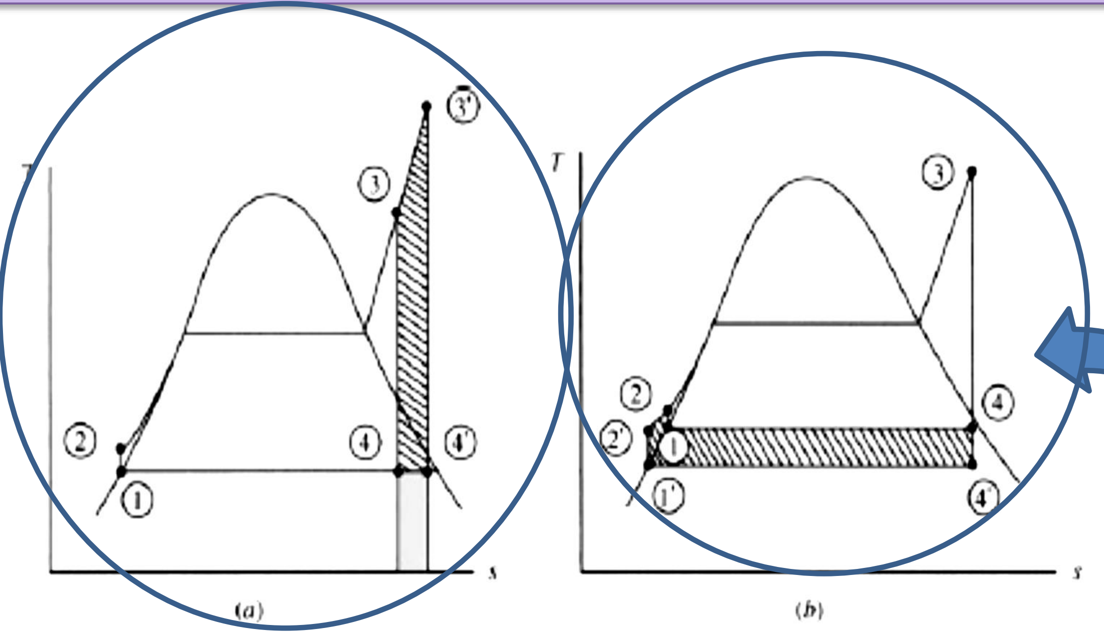
Increasing the boiler pressure while maintaining the **maximum temperature** and the **minimum pressure**.



Problem with moisture at turbine outlet.

IMPROVING THE RANKINE CYCLE EFFICIENCY

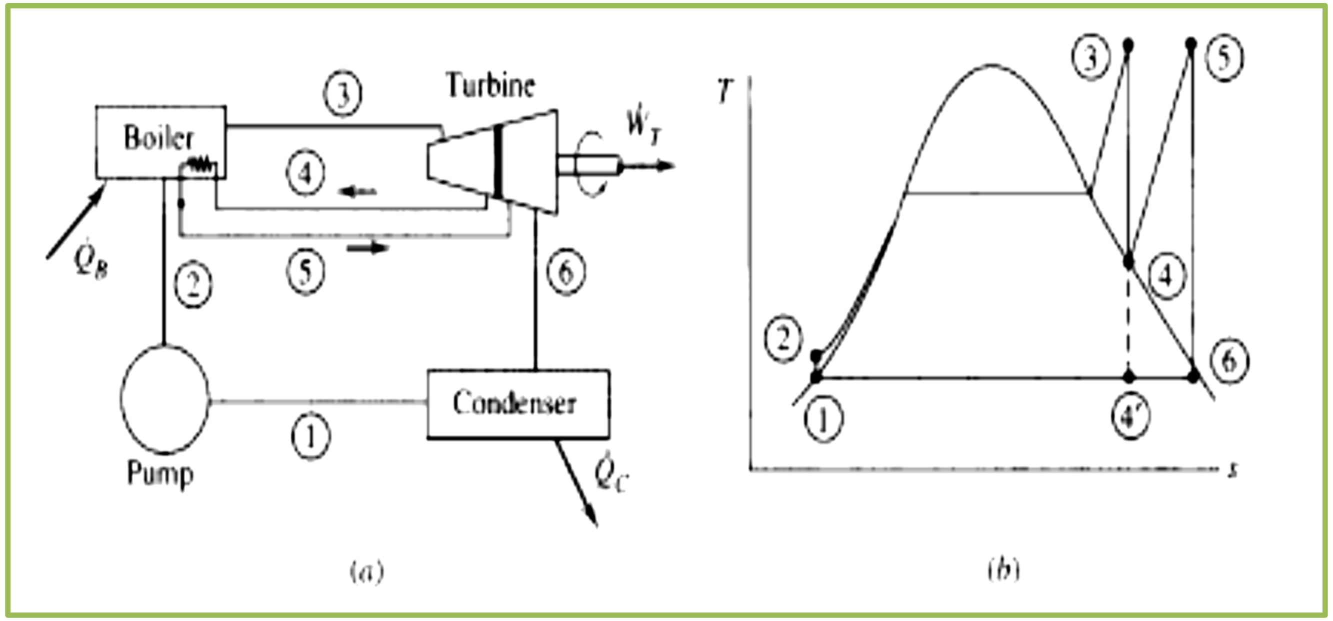
Increasing the maximum temperature – also results in higher steam quality at turbine exit



A decrease in condenser pressure improves efficiency, but creates risk of ambient air infiltration into condenser and lower exit steam quality

IMPROVING THE RANKINE CYCLE EFFICIENCY

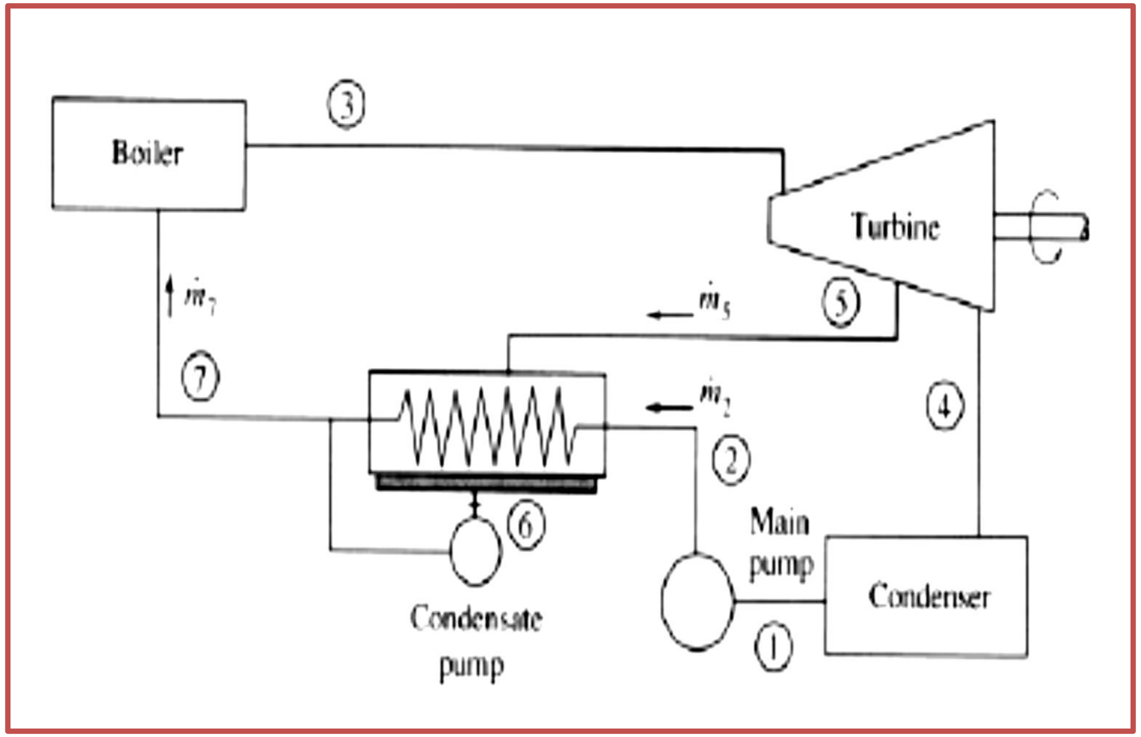
Reheat – solves the problem of moisture with increased boiler pressure or reduced condenser pressure.

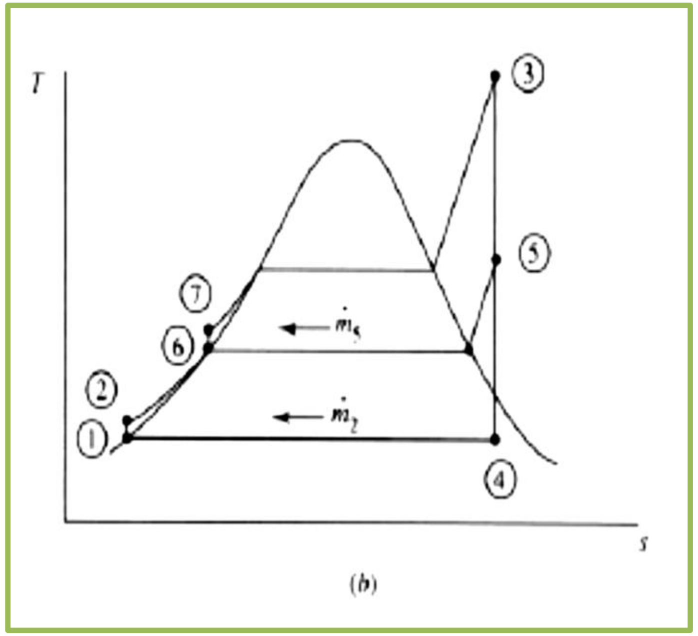


Rankine cycle with reheat

IMPROVING THE RANKINE CYCLE EFFICIENCY

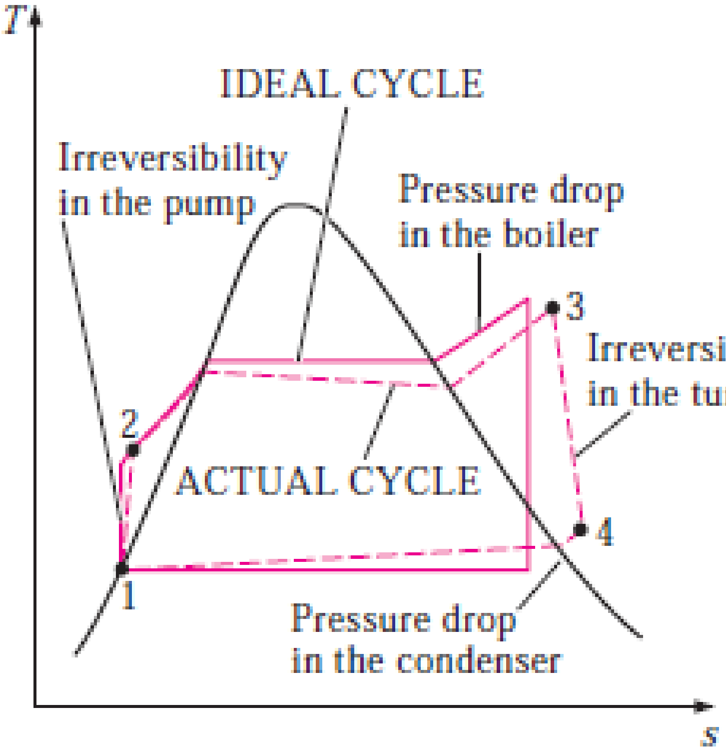
Regeneration

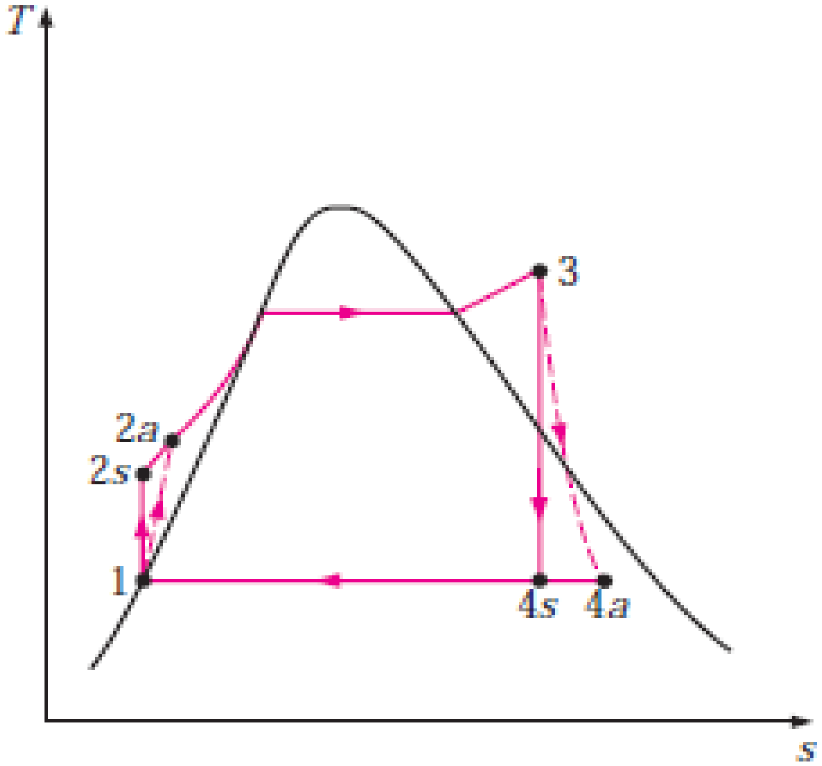




This technique taps some of the steam expanding in the turbine to preheat water entering the boiler. The net effect is a reduced heat input at the boiler side

EFFECT OF LOSSES ON POWER CYCLE EFFICIENCY





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

More input that ideal case.

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

Less output than ideal case.