Power Cycles

Episode 2

Reheat Rankine Cycle with Multi-Stage Expansion

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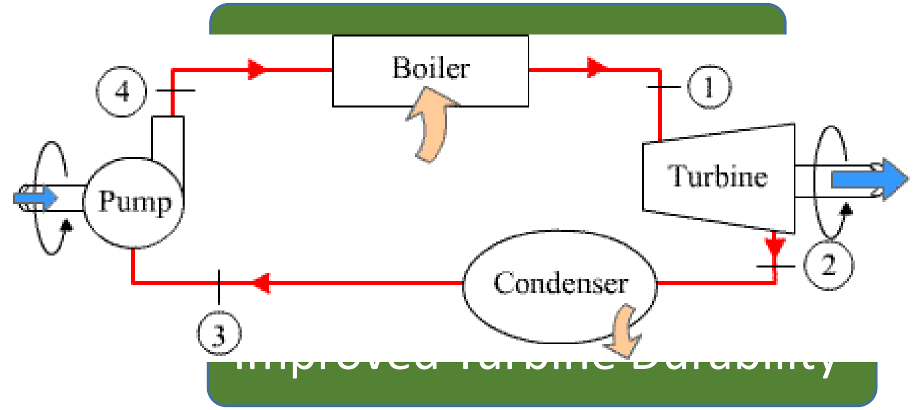
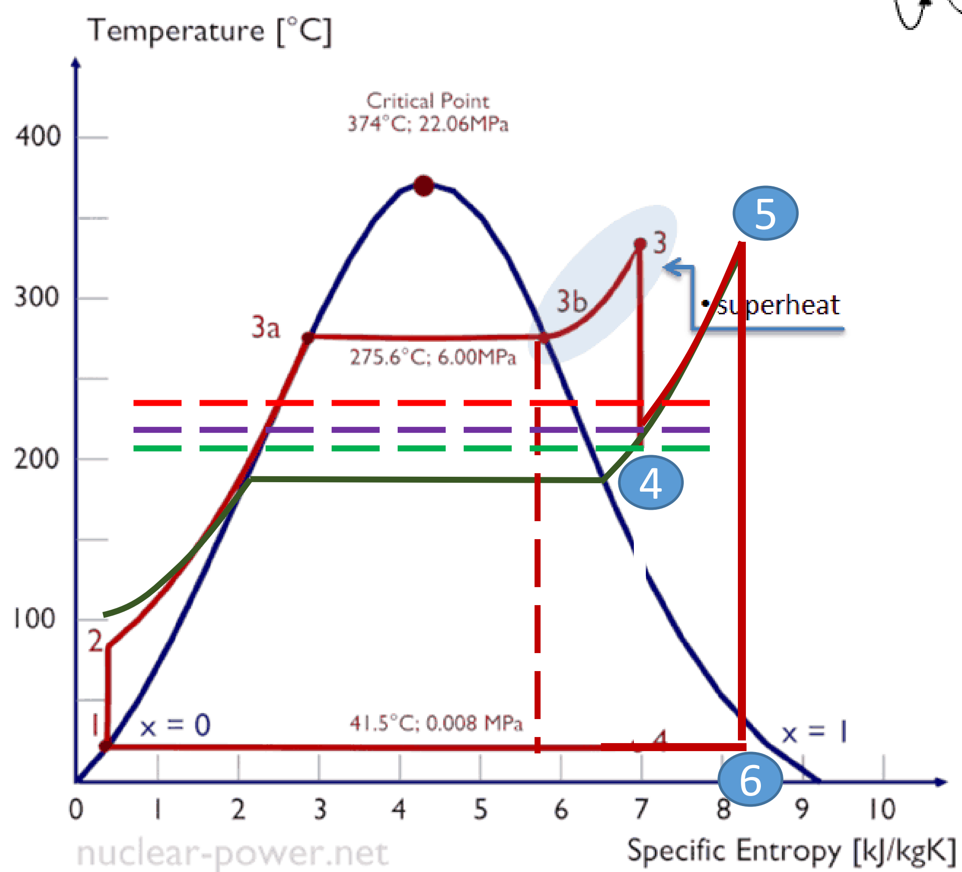
Reheat Cycle





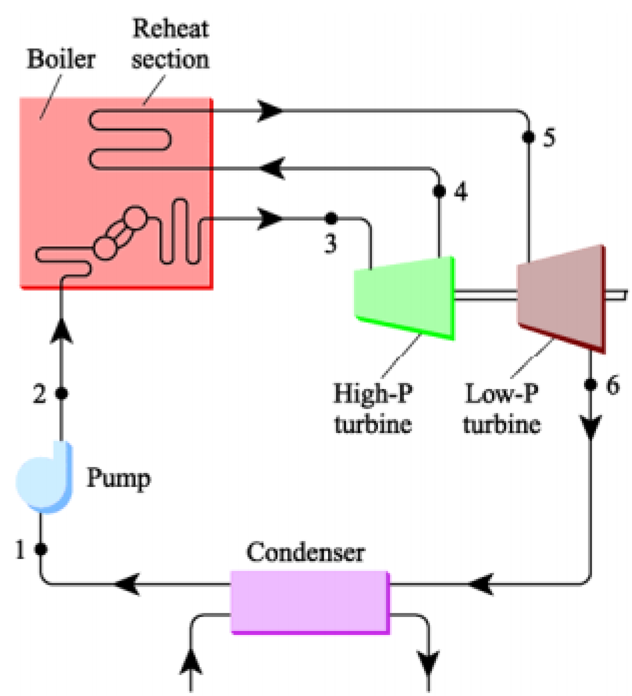


Image Source: www.nuclear-power.net ; www.chegg.com ; http://romulus.sdsu.edu/

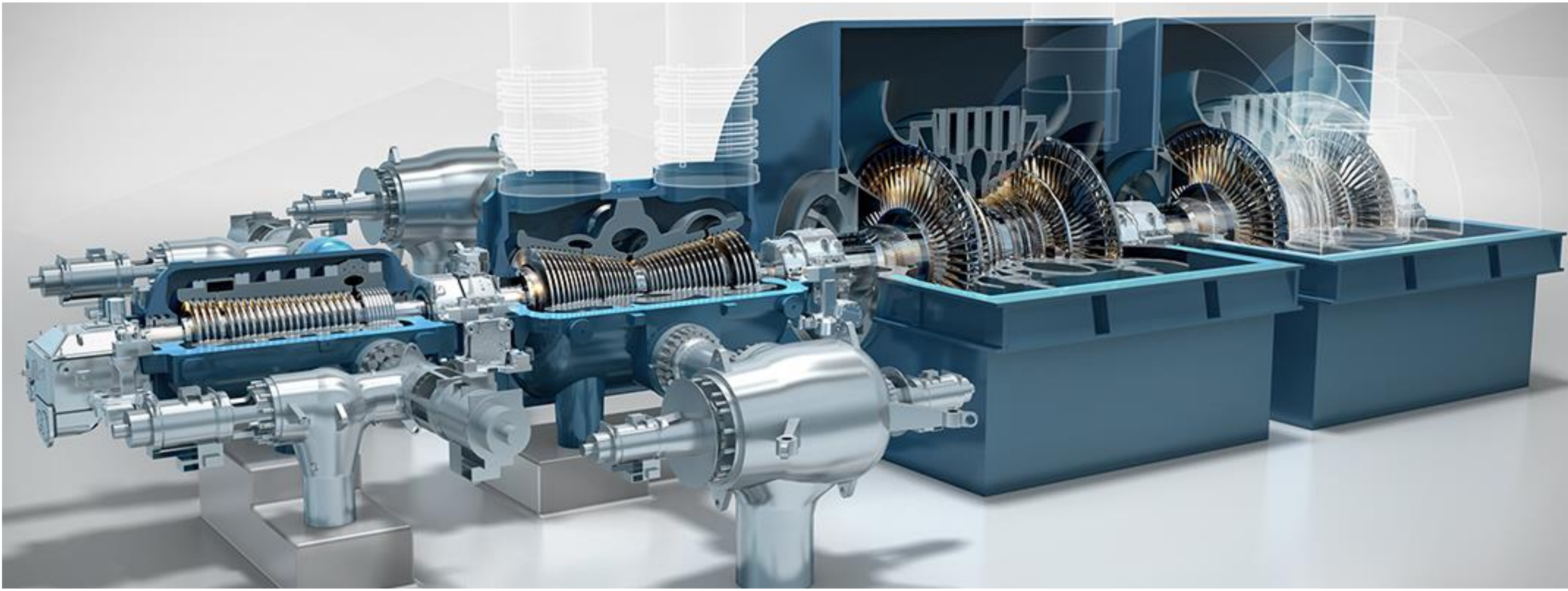


Image source: www.ge.com

Sketch the T-s diagram of a steam power plant having three stages of expansion (HP, IP, and LP) with reheat. Assume ideal operation.

Quiz:

Example

A steam power plant produces a net power output of 100 MW. The boiler is maintained at 50 bar and steam is superheated to 500 °C before entering the high-pressure (HP) stage turbine. Steam expands through HP stage until the pressure drops to 10 bar and then it is re-heated to 500 °C before entering the low-pressure (LP) stage turbine. In the LP stage, steam is expanded until it reaches the condenser pressure of 0.05 bar. Steam leaves the condenser as a saturated liquid. The isentropic efficiency of HP, LP and feed-pump are 80%, 75%, and 95%, respectively. With suitable assumptions,

Determine:

(a) The condition of steam (whether superheated or wet vapour) at the exit of LP stage

(b) Thermal efficiency of the cycle

(c) Mass flow rate of steam

Example

At 10 bar	entropy
s_a	6.926
s_b	7.124
h_a	2944
h_b	3052

$h_3 = 3433$ kJ/kg

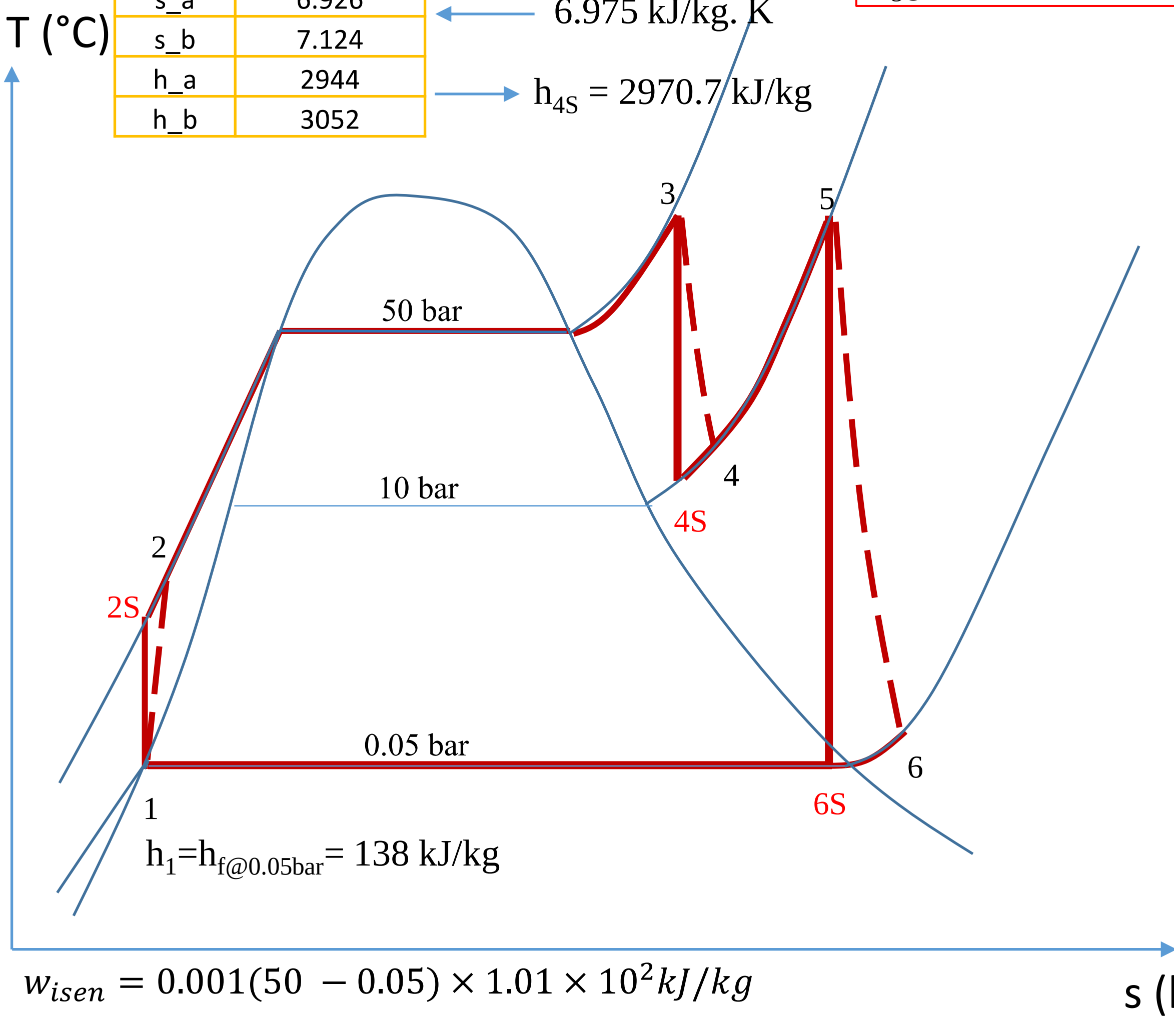
$s_3 = 6.975$ kJ/kg. K

$s_{4S} = s_3 = 6.975$ kJ/kg. K

$s_{g@10bar} = 6.586$ kJ/kg. K

6.975 kJ/kg. K

$h_{4S} = 2970.7$ kJ/kg

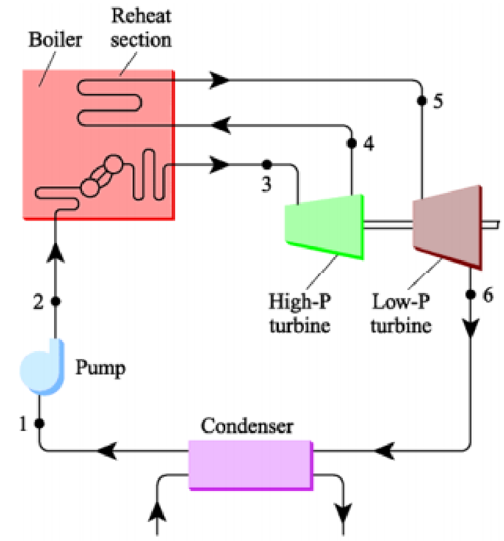


$h_1 = h_{f@0.05bar} = 138$ kJ/kg

$$w_{isen} = 0.001(50 - 0.05) \times 1.01 \times 10^2 kJ/kg$$

$$w_{actual} = \frac{w_{isen}}{0.75} = 5.3\ kJ/kg$$

$h_2 = 143.3$ kJ/kg



$$\frac{h_3 - h_4}{h_3 - h_{4S}} = 0.8$$

$h_4 = 3063.2$ kJ/kg

$h_5 = 3478$ kJ/kg

$s_5 = 7.761$ kJ/kg. K

$s_{6S} = s_5 = 7.761$ kJ/kg. K

$s_{g@0.05bar} = 8.394$ kJ/kg. K

$X_{6S} = 0.9200$

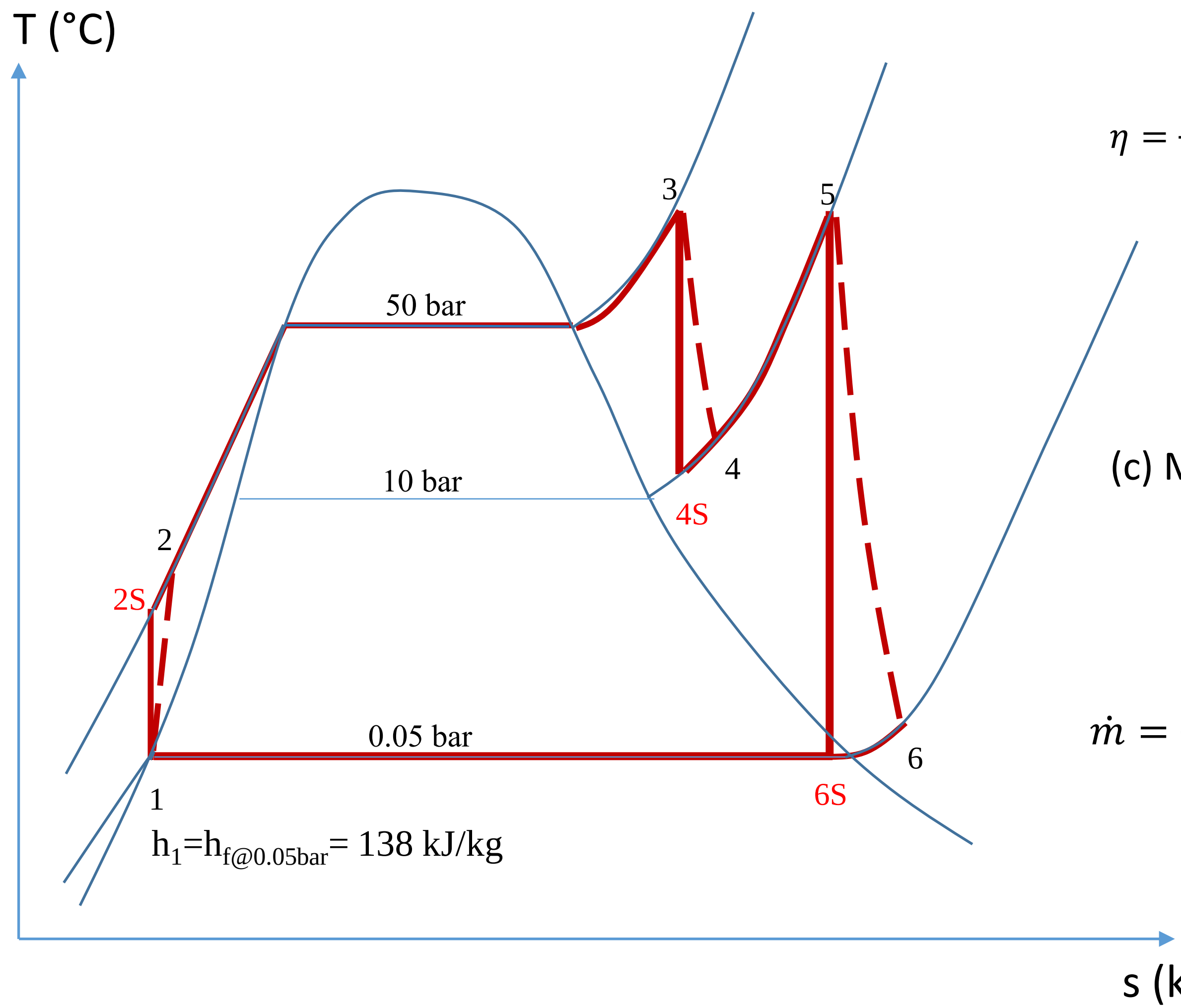
$h_{6S} = 2367.2$ kJ/kg

$$\frac{h_5 - h_6}{h_3 - h_{6S}} = 0.75$$

$h_6 = 2645$ kJ/kg

Image Source: http://romulus.sdsu.edu/

Example



(a) Super heated steam

(b) Thermal efficiency

$$\eta = \frac{w_{out} - w_{in}}{q_{in}}$$

$$\eta = \frac{(h_3 - h_4) + (h_5 - h_6) - w_{pump}}{(h_3 - h_2) + (h_5 - h_4)}$$

$$\eta = 32.33\%$$

(c) Mass flow rate

$$\dot{m} = \frac{Power\ Output}{w_{net}}$$

$$\dot{m} = \frac{100 \times 100\ kW}{(h_3 - h_4) + (h_5 - h_6) - w_{pump}\ kJ/kg}$$

$$\dot{m} = 83.51\ kg/s$$

Rankine Cycle with Re-heat

Performance Analysis

Image Source :http://clipart-library.com/