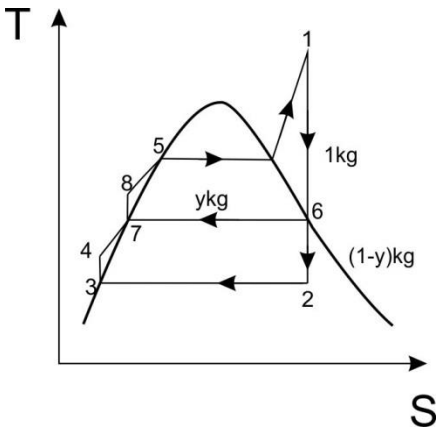
Example 4

If the Rankine Cycle in example 1 is modified to include a FWH, calculate the cycle efficiency and the SSC. Feed pumps can be neglected.

Steam enter turbine at 42 bars, dry saturated and condenser pressure is 0.035bar.



$T_{1@42bar} = 526.2K@253.2°C$

$T_{2@0.035bar} = 299.7K@26.7°C$

It is necessary to determine the bleed pressure when one or more FWH are installed.

$$T_{6@bleed} = \frac{T_{s,boiler} + T_{s,condensor}}{2} = \frac{T_5 + T_2}{2} = \frac{253.2 + 26.7}{2} = 139.95°C$$

$T_{6@bleed}$ needto be calculatedwhen pressureand temperetue usedin FWHarenot provided

$P_{6@139.95°C} = 3.6bar$

Knowing from example 1

$h_{3,f,0.035bar} = 111.8\ kJ/kg$

$s_{1,g} = s_2 = s_6 = 6.05\ kJ/kg$

$s = s_f + xs_{fg}$

$$\Rightarrow x_2 = \frac{s_2 - s_{f,2}}{s_{fg,2}} = \frac{6.05 - 0.391}{(8.5225 - 0.391)} = 0.696$$

$$\Rightarrow x_6 = \frac{s_6 - s_{f,6}}{s_{fg,6}} = \frac{6.05 - 1.738}{(6.9312 - 1.738)} = 0.83$$

$$h_6 = h_{f,6} + x_6 h_{fg,6} = 588.52 + [0.83 \times 2145.12] = 2369.27\ \text{kJ/kg}$$
$$h_2 = h_{f,2} + x_6 h_{fg,2} = 111.88 + [0.696 \times 2438.45] = 1809.02\ \text{kJ/kg}$$
$$h_{7,f} = 588.52\ \text{kJ/kg} \qquad (\text{From steam table})$$

To determine the fraction, y consider the adiabatic mixing process at FWH *y*kg of the steam of h_6 mix with (1-y)kg of water h_3 to give 1kg of water of h_7.

Feed pump can be neglected (h_4=h_3)

$$yh_6 + (1-y)h_4 = h_7$$
$$y(h_6 - h_4) = h_7 - h_4$$
$$y = \frac{h_7 - h_4}{h_6 - h_4} = \frac{h_7 - h_{3f}}{h_6 - h_{3f}} = \frac{588.52 - 111.8}{2369.27 - 111.8} = 0.2112$$

Second feed pump also can be neglected (h_7=h_8)

$$h_{1,g} = 2799.9\ \text{kJ/kg}$$
$$q_{in} = 2799.6 - 588.52 = 2211.08\ \text{kJ/kg}$$

$$w_{out} = w_{16} + w_{62} = (h_1 - h_6) + (1-y)(h_6 - h_2) = (2799.6 - 2369.27) + (1 - 0.2112)(2369.27 - 1809.02) = 872.3\ \text{kJ/kg}$$

$$\eta = \frac{W_{net}}{q_{in}} = \frac{872.3}{2211.08} = 0.3945 @ 39.45\%$$
$$\text{SSC} = \frac{3600}{872.3} = 4.13\ \text{kg/kWhr}$$

Compare the example 1, a FWH has increased the efficiency from 36.76% (Rankine cycle) to 39.45%, but SSC also increase from 3.65kJ/kWhr (Rankine cycle) to 4.13kJ/kWhr. Efficiency increased with the addition of extra heater but capital expenditure also increase since a feed pump is required with each FWH.