Goal: Want to generate 1000 MW ($1x10^6$ kJ/s) of Electricity.

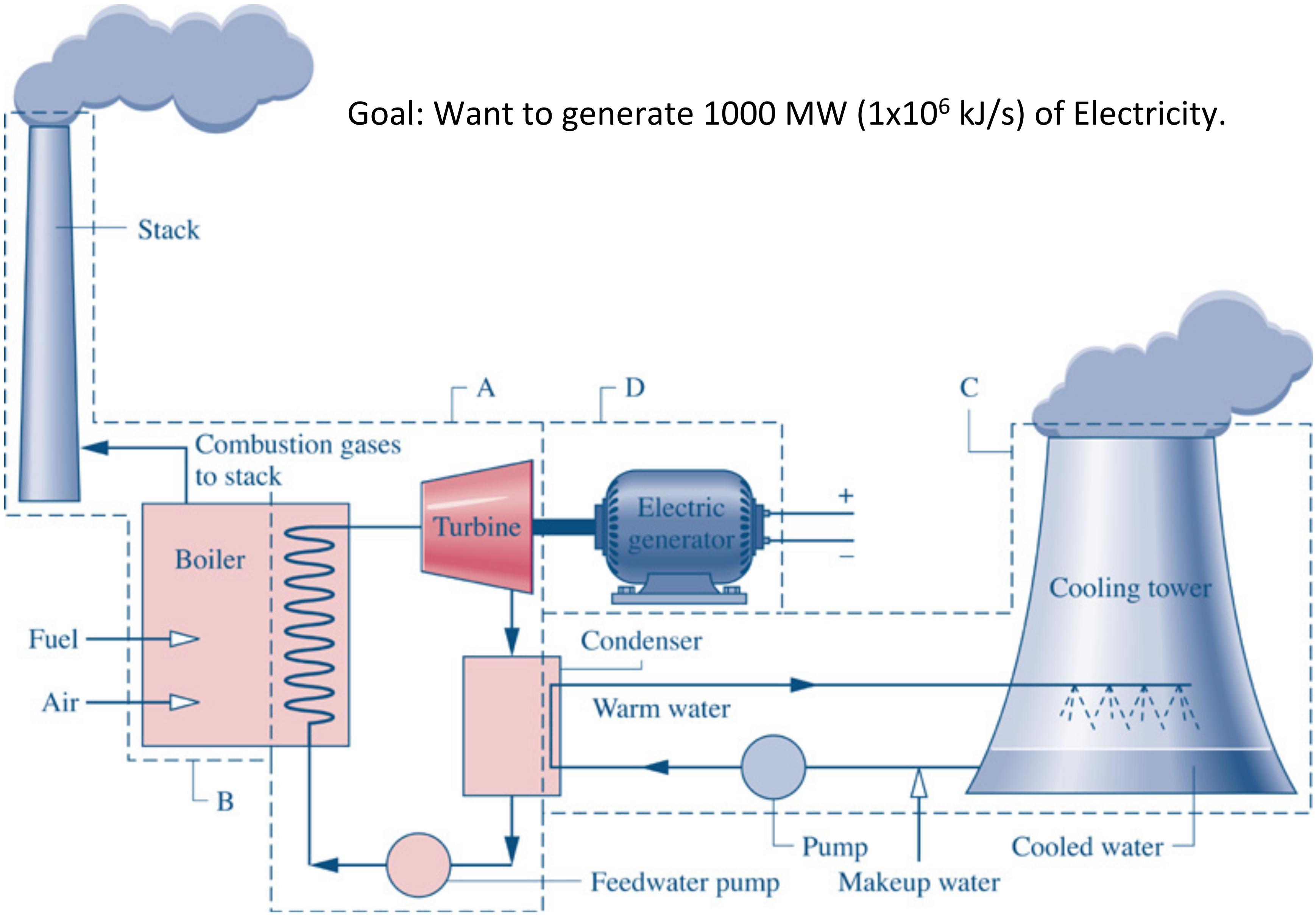
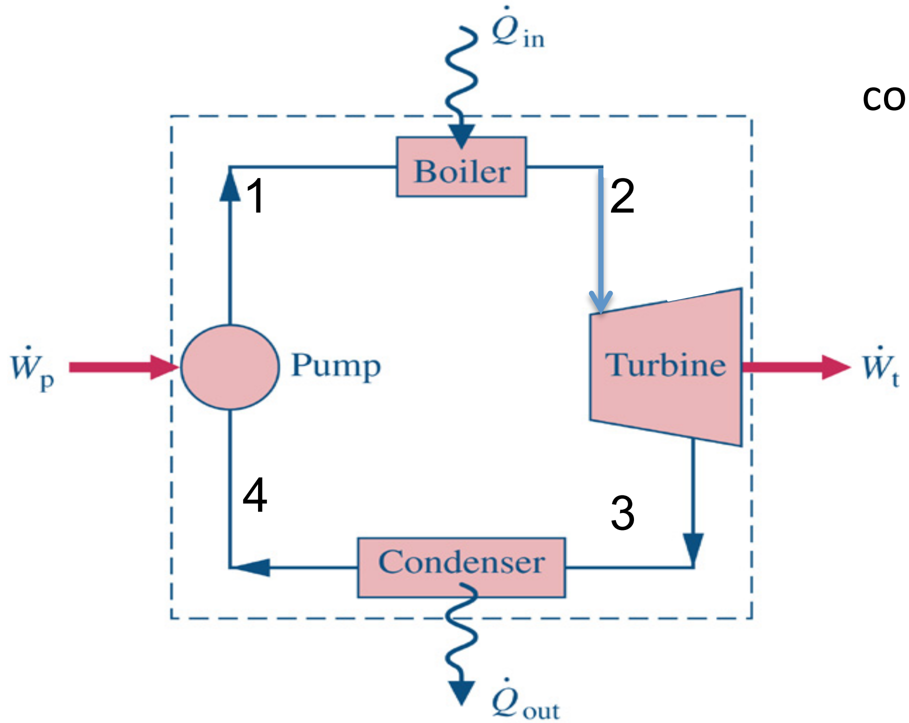


Fig08_01

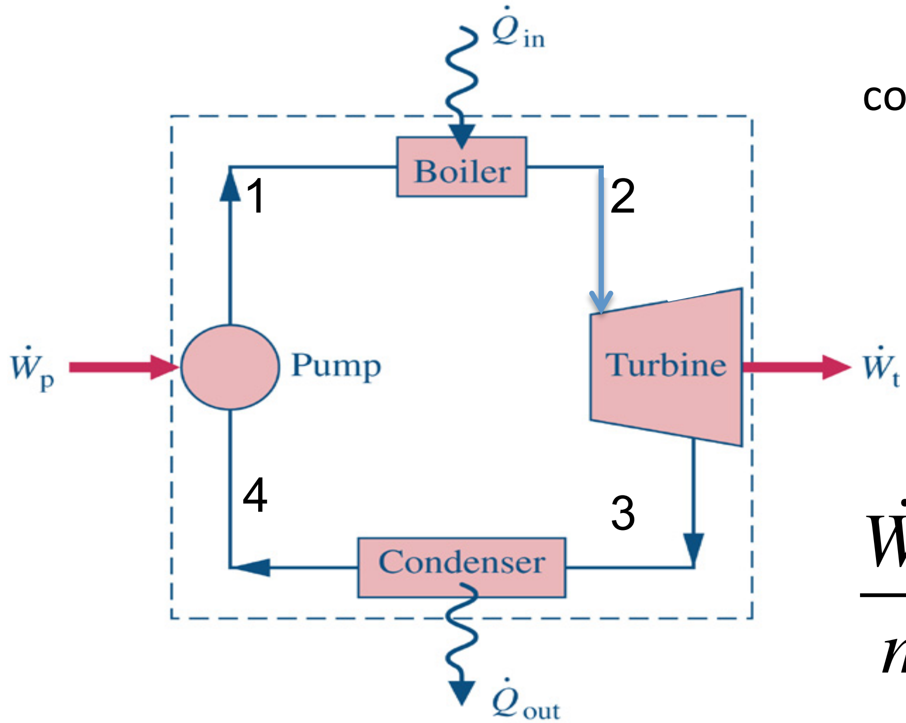


Consider a system similar to what the components that we've just analyzed in class.

Assume ideal conditions initially

Look up state 2 properties

	P (bar)	T (deg. C)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kgK)	x
1							
2	40	478					
3	.6						.92
4							



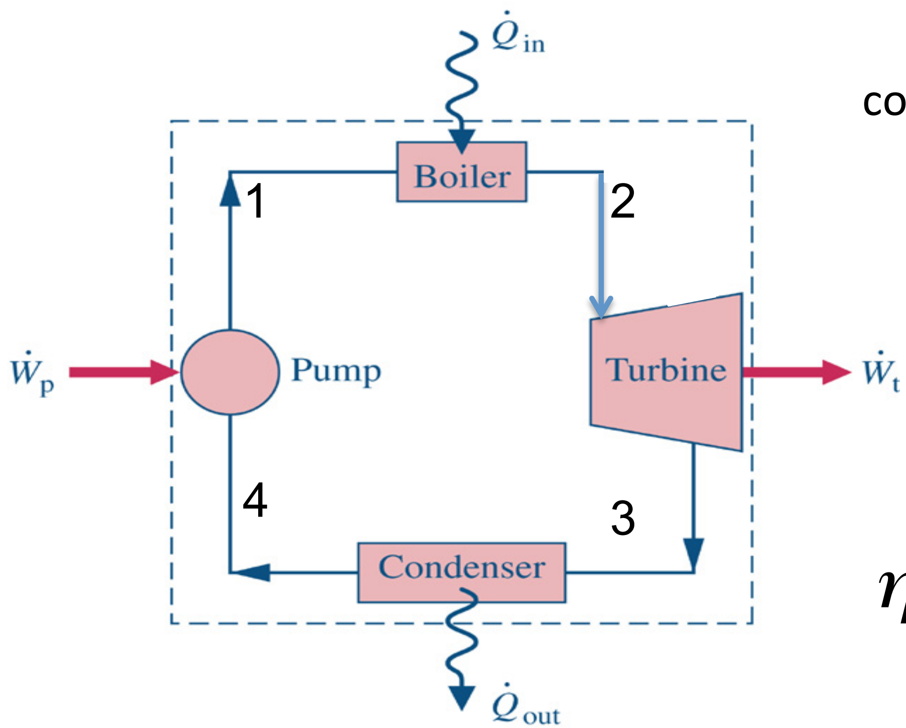
Consider a system similar to what the components that we've just analyzed in class.

Assume ideal conditions initially

Look up state properties

$$\frac{\dot{W}_P}{\dot{m}} = v(P_1 - P_4) \text{ Work Added}$$

	P (bar)	T (deg. C)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kgK)	x
1	40	86.91	.0010338	355.84	363.93	1.1565	Liq
2	40	478	.083603	3060.16	3394.63	7.0219	SH
3	.6	85.94	2.51352	2319.22	2469.97	7.0211	.92
4	.6	85.94	.0010331	359.79	359.86	1.1453	0



Consider a system similar to what the components that we've just analyzed in class.

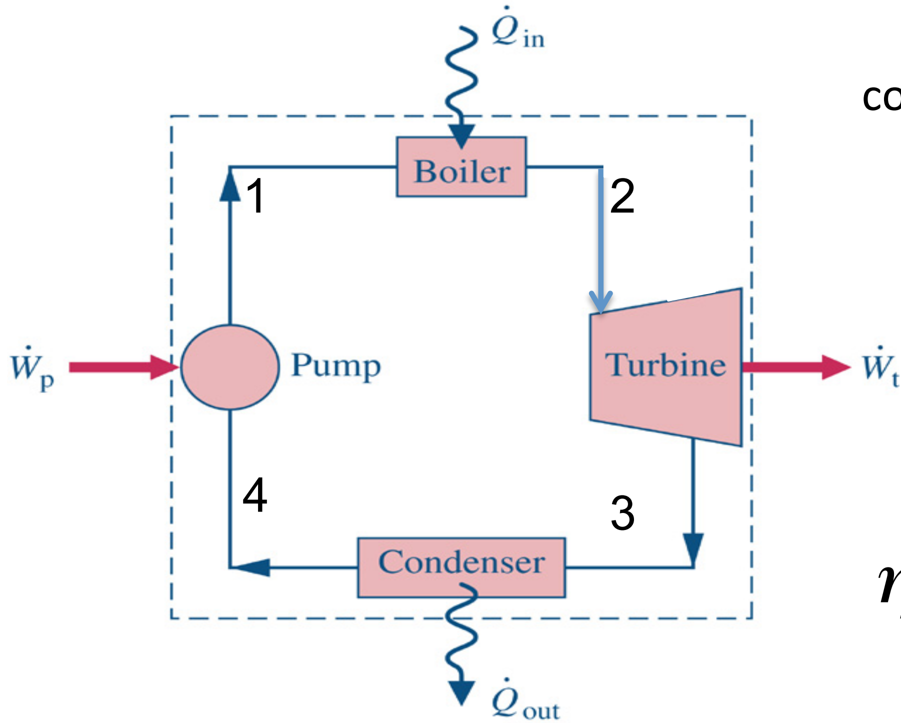
How to address actual conditions?

A) Measure/observe any two independent state properties and look up the rest.

B) Use reasonable efficiency estimates for each device

$$\eta_P = \frac{\dot{W}_{\text{P-Ideal}}}{\dot{W}_{\text{P-Actual}}} \qquad \eta_T = \frac{\dot{W}_{T\text{-Actual}}}{\dot{W}_{\text{T-Ideal}}}$$

	P (bar)	**T (deg. C)**	**v m^3/kg**	**u kJ/kg**	**h kJ/kg**	**s kJ/(kgK)**	**x**
1							
2	40	478					
3	.6					?	?
4							



Consider a system similar to what the components that we've just analyzed in class.

How to address actual conditions?

A) Measure/observe any two independent state properties and look up the rest.

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$$\eta_P = \frac{\dot{W}_{\text{P-Ideal}}}{\dot{W}_{\text{P-Actual}}} \qquad \eta_T = \frac{\dot{W}_{T\text{-Actual}}}{\dot{W}_{\text{T-Ideal}}}$$

$$\eta_T = 0.90$$

	P (bar)	T (deg. C)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kgK)	x
1							
2	40	478					
3	.6					?	?
4							

$$\eta_T = 0.90 = \frac{\dot{W}_{T\text{-Actual}}}{\dot{W}_{\text{T-Ideal}}} = \frac{h_2 - h_3}{h_2 - h_{3-Ideal}}$$

What is $h_{(3\text{-Ideal})}$?

$$\eta_T = 0.90 = \frac{\dot{W}_{T\text{-Actual}}}{\dot{W}_{\text{T-Ideal}}} = \frac{h_2 - h_3}{h_2 - h_{3-Ideal}}$$

What is $h_{(3\text{-Ideal})}$? $$s_3 = s_2 = 7.0219 = s_f + x(s_g - s_f)$$

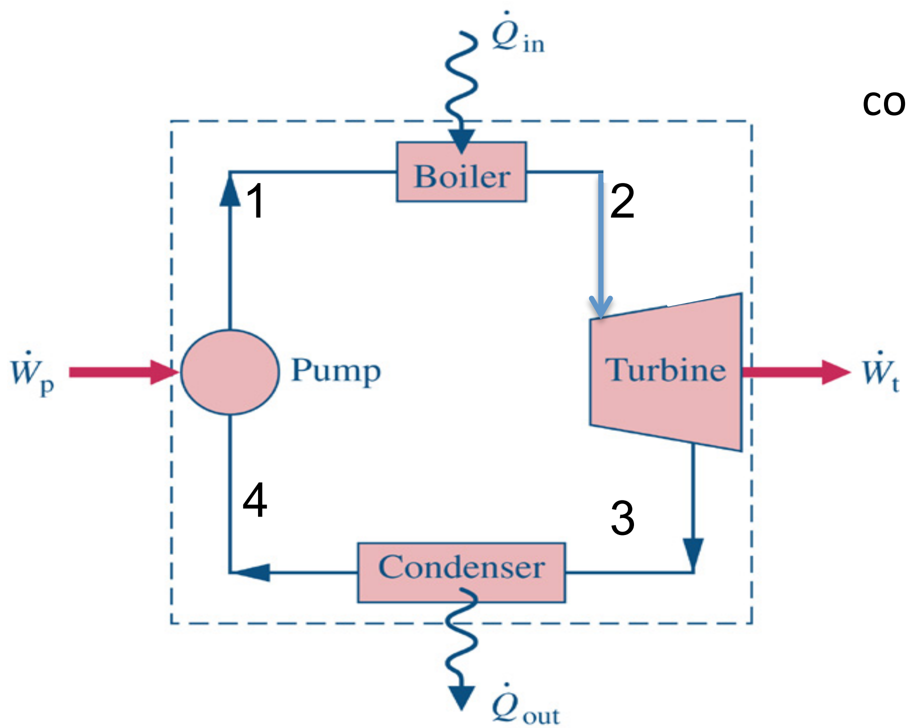
$$s_3 = 7.0219 = s_f + x(s_g - s_f) = 1.1453 + x(7.5320 - 1.1453)$$

$$x = 1.1453 + x(7.5320 - 1.1453) = .92$$

$$h_{3-Ideal} = h_f + x(h_g - h_f) = 359.86 + .92(2293.6) = 2469.97$$

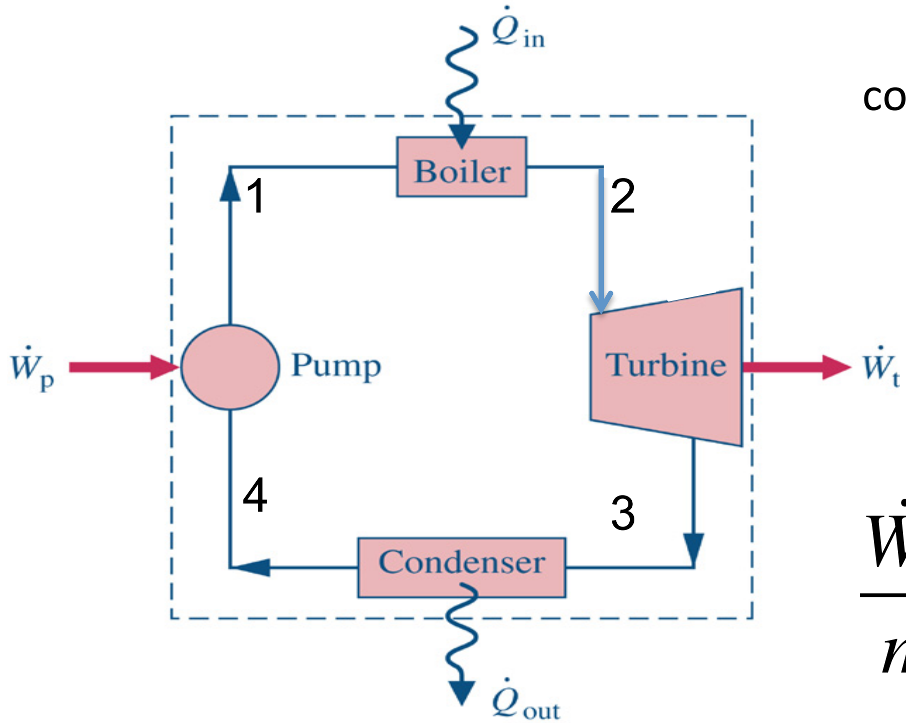
$$\left(h_2 - h_{3-Ideal}\right)\eta_P = h_2 - h_{3-Actual} \quad h_{3-Actual} = 2562.44\frac{kJ}{kg}$$

$$h_{3-Actual} = h_f + x(h_g - h_f) = 359.86 + x(2293.6) = 2562.44 \quad x = 0.96$$



Consider a system similar to what the components that we've just analyzed in class.

	P (bar)	T (deg. C)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kgK)	x
1							
2	40	478	.083603	3060.16	3394.63	7.0219	SH
3	.6	85.94	2.6228	2404.41	2562.44	7.27653	.96
4	.6	85.94	.0010331	359.79	359.86	1.1453	0



Consider a system similar to what the components that we've just analyzed in class.

$$\frac{\dot{W}_P}{\dot{m}} = v(P_1 - P_4) \text{ Work Added}$$

	P (bar)	T (deg. C)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kgK)	x
1							
2	40	478	.083603	3060.16	3394.63	7.0219	SH
3	.6	85.94	2.6228	2404.41	2562.44	7.27653	.96
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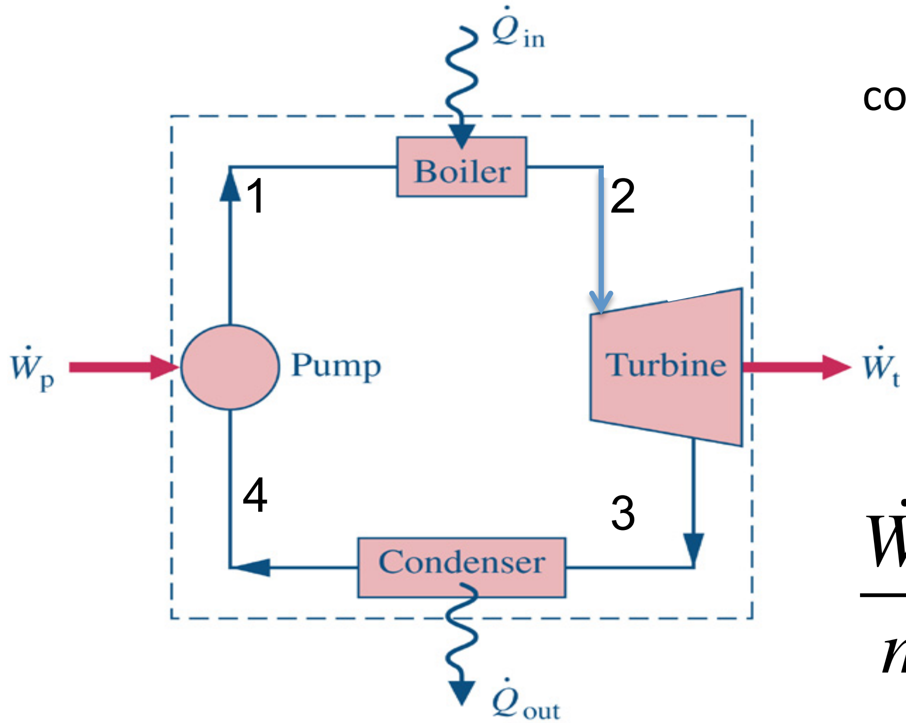


Consider a system similar to what the components that we've just analyzed in class.

$$\frac{\dot{W}_P}{\dot{m}} = v(P_1 - P_4)\text{ Work Added}$$

$$\eta_P = 0.95$$

	P (bar)	T (deg. C)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kgK)	x
1							
2	40	478	.083603	3060.16	3394.63	7.0219	SH
3	.6	85.94	2.6228	2404.41	2562.44	7.27653	.96
4	.6	85.94	.0010331	359.79	359.86	1.1453	0

$$\eta_P = 0.90 = \frac{\dot{W}_{P\text{-Ideal}}}{\dot{W}_{P\text{-Actual}}}$$

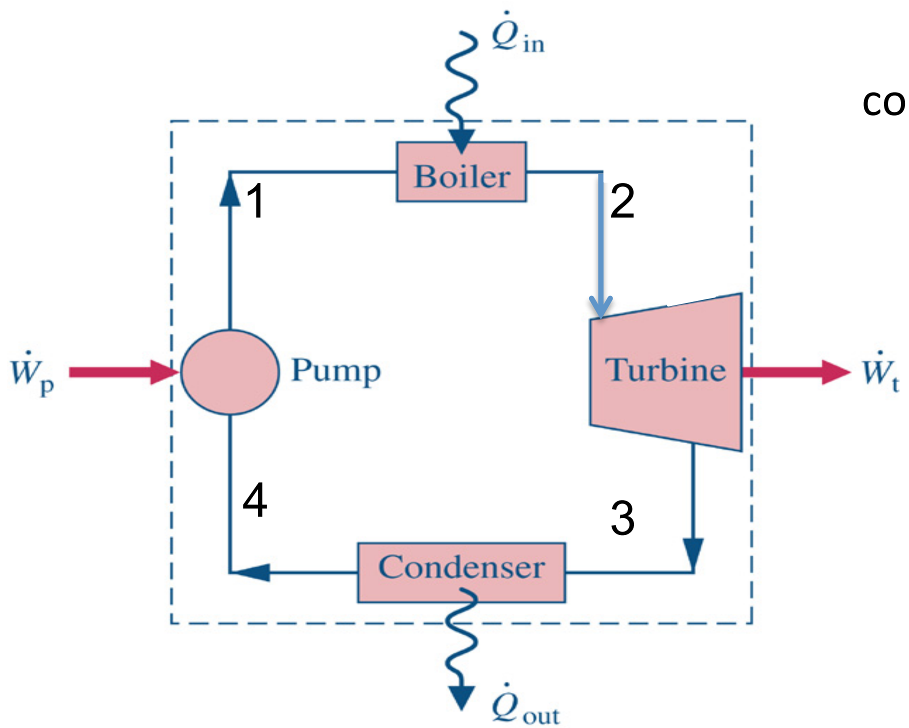
$$\frac{\dot{W}_{P-Ideal}}{\dot{m}} = v(P_1 - P_4)$$ Work Added

$$\frac{\dot{W}_{P-Actual}}{\dot{m}} = \frac{v(P_1 - P_4)}{0.95} = \left(.0010331\frac{m^3}{kg}(40 - .6)bar10^5\frac{N/m^2}{bar}10^{-3}\frac{kJ}{Nm}\right)/.95$$

$$\frac{\dot{W}_{P-Actual}}{\dot{m}} = \frac{v(P_1 - P_4)}{0.95} = 4.285\frac{kJ}{kg}$$

$$h_1 = h_4 + W_{Pump} = 359.86 + 4.285 = 364.15\frac{kJ}{kg}$$

$$T_1 = function(h_1 = h_f\ at\ T_1) = 87.5^oC$$



Consider a system similar to what the components that we've just analyzed in class.

	P (bar)	T (deg. C)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kgK)	x
1	40	87.5			364.15		
2	40	478	.083603	3060.16	3394.63	7.0219	SH
3	.6	85.94	2.6228	2404.41	2562.44	7.27653	.96
4	.6	85.94	.0010331	359.79	359.86	1.1453	0

Performance ?

$$\eta = \frac{\dot{W}_{Net}}{\dot{Q}_{\text{In}}} = \frac{\dot{Q}_{\text{In}} - \dot{Q}_{out}}{\dot{Q}_{\text{In}}} \qquad \eta_{Ideal} = \frac{(3394.63 - 2469.97) - (363.93 - 359.86)}{(3394.63 - 363.93)} = \frac{920.6}{3030.7} = 30.38\%$$

$$\eta = \frac{\dot{W}_{Net}}{\dot{Q}_{\text{In}}} = \frac{\dot{Q}_{\text{In}} - \dot{Q}_{out}}{\dot{Q}_{\text{In}}} \qquad \eta_{Actual} = \frac{(3394.63 - 2562.44) - (364.15 - 359.86)}{(3394.63 - 364.15)} = \frac{827.9}{3030.5} = 27.32\%$$

$$\eta_{Max} = 1 - \frac{T_C}{T_H} = 1 - \frac{87.5 + 273.15}{478 + 273.15} = 1 - .48 = 52\%$$