CICLO DE RANKINE IDEAL

EXERCÍCIO

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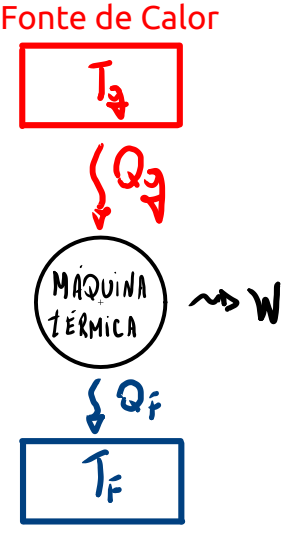
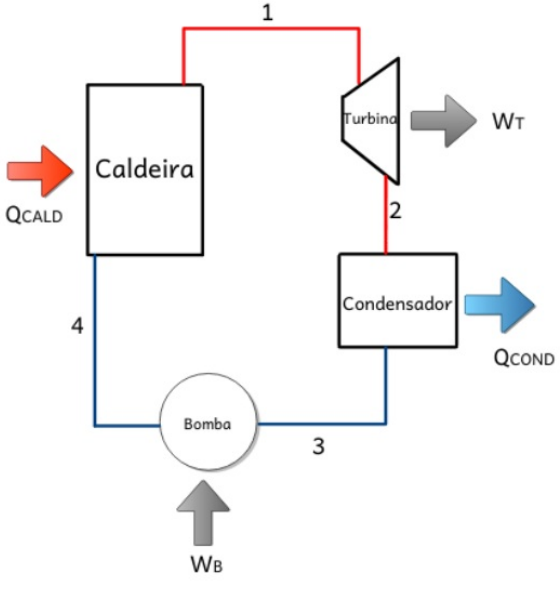
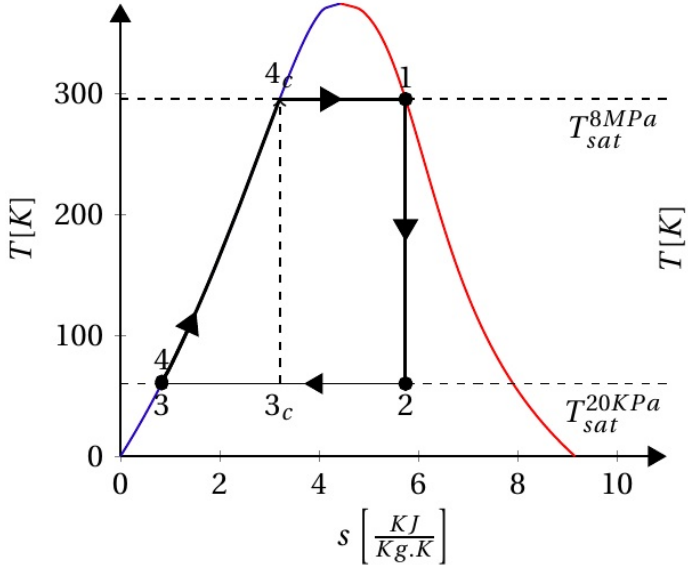




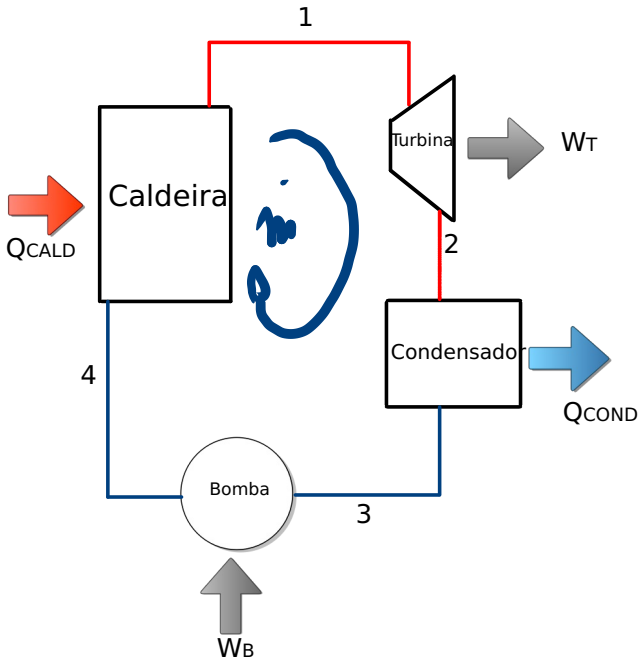


Ciclo de geração de Potência a Vapor de Rankine

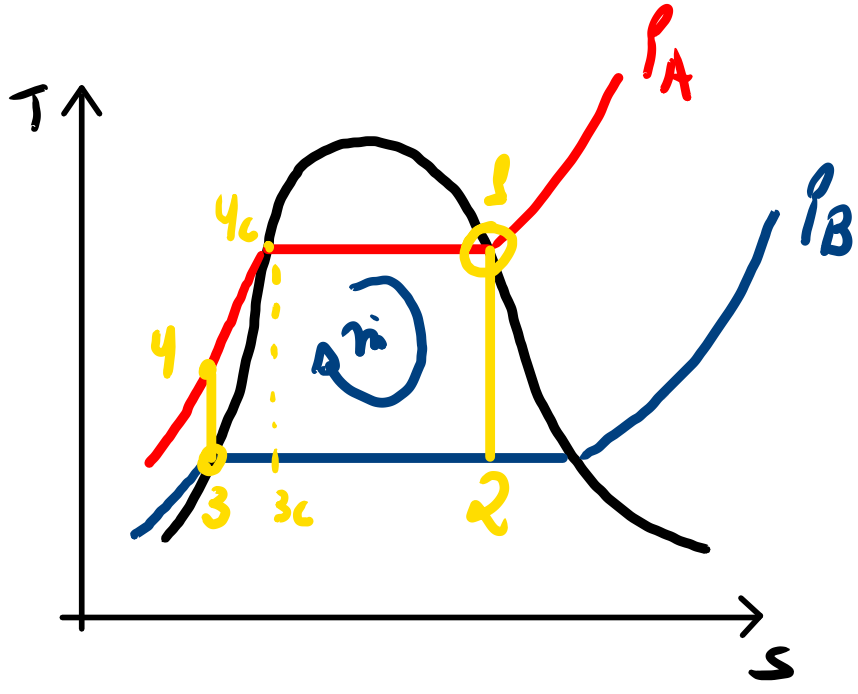
Água é o fluido de trabalho em um ciclo de potência a vapor de Rankine ideal. Vapor saturado entra na turbina a 8 [MPa] e liquido saturado entra na bomba a 20 [KPa]. Determine:

a) Trabalho desenvolvido pela turbina e bomba
b) Transferência de calor na caldeira e no condensador
c) bwr
d) Eficiência térmica
e) Eficiência de Carnot

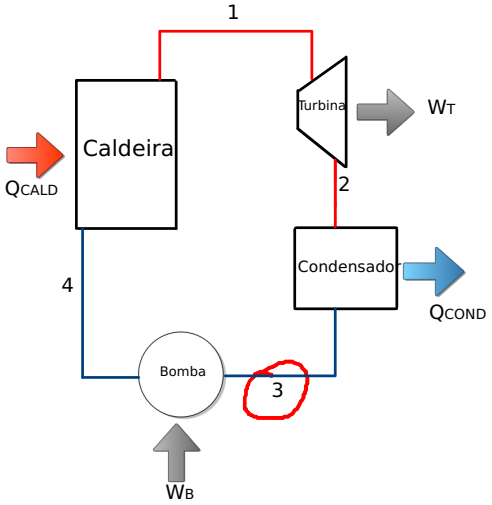
1. Desenhe os componentes do ciclo e identifique-os



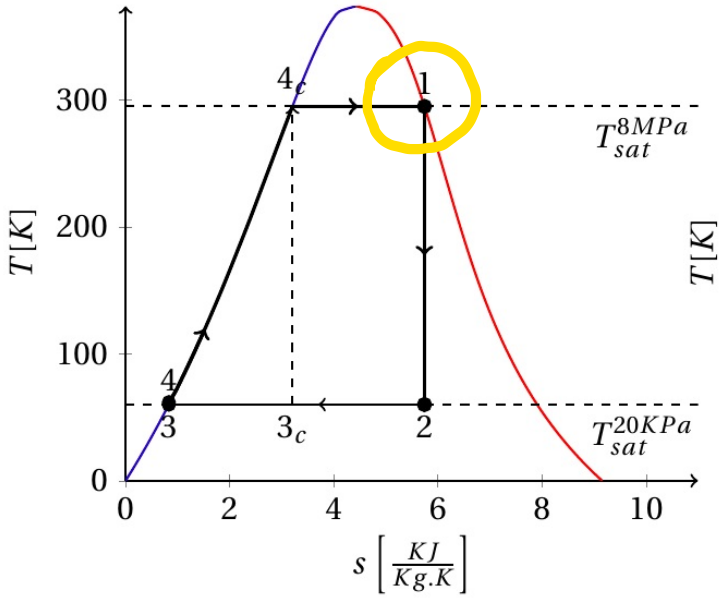
2. Desenhe o diagrama T-s

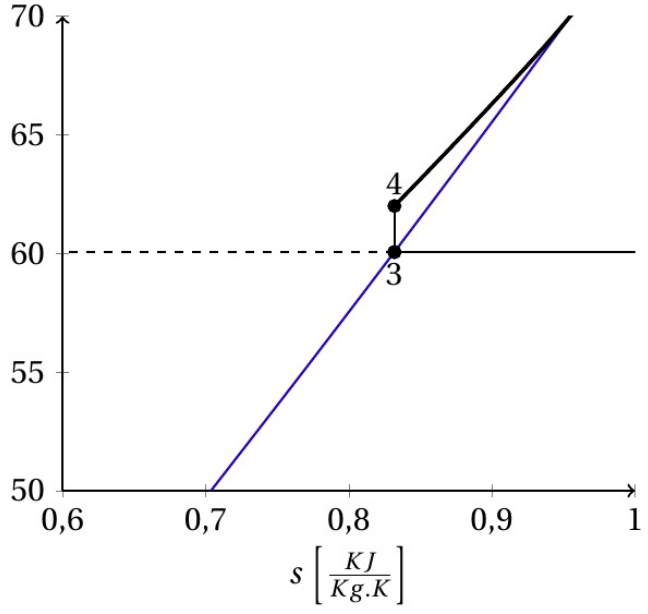


1. Desenhe os componentes do ciclo e identifique-os



2. Desenhe o diagrama T-s



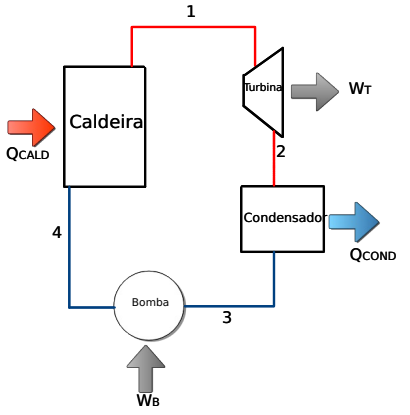


3. Faça uma tabela dos estados

Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	$T_S(P_1)$	1	~	h_V	s_V
2	20	$T_S(P_2)$		~		$= s_1$
3	20	$T_S(P_3)$	0	v_3	h_L	s_L
4	8000	?		~		$= s_3$

4. Preencha os valores conhecidos na tabela

Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	T_{s1}	1	$v_1 = v_v$	$h_1 = h_v$	$s_1 = s_v$
2	20					$s_2 = s_1$
3	20	T_{s3}	0	$v_3 = v_L$	$h_3 = h_L$	$s_3 = s_L$
4	8000					$s_4 = s_3$

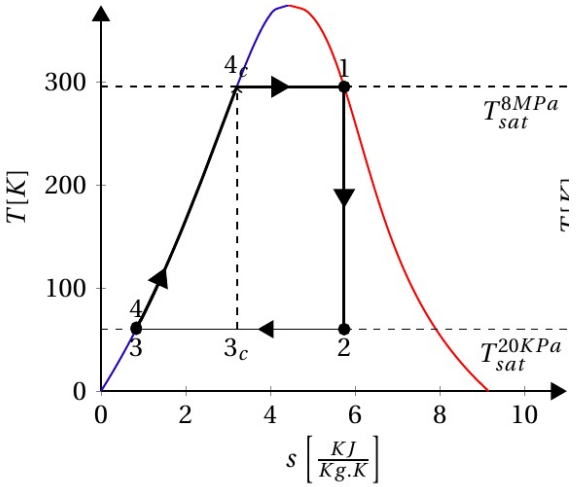


5. Calcule as propriedades restantes

P	T	v_L	v_V	u_L	u_{LV}	u_V	h_L	h_{LV}	h_V	s_L	s_{LV}	s_V
7000	285,88	0,001351	0,02737	1257,51	1322,97	2580,48	1266,97	1505,10	2772,07	3,1210	2,6922	5,8132
8000	295,06	0,001384	0,02352	1305,54	1264,25	2569,79	1316,61	1441,33	2757,94	3,2067	2,5365	5,7431
9000	303,40	0,001418	0,02048	1350,47	1207,28	2557,75	1363,23	1378,88	2742,11	3,2857	2,3915	5,6771

3. Faça uma tabela dos estados

Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	295,06	1	~	2757,94	5,7431
2	20			~		5,7431
3	20		0			
4	8000			~		



3. Faça uma tabela dos estados

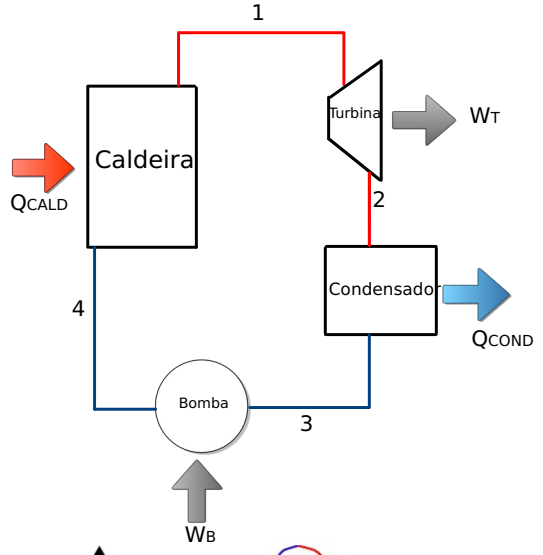
Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	235,06	1	~	2757,94	5,7431
2	20	60,06		~		5,7431
3	20	60,06	0	v_L	h_L	s_L
4	8000			~		

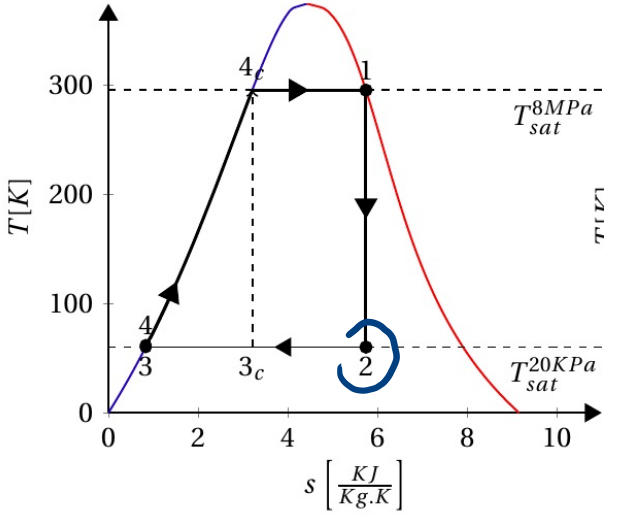
P	T	v_L	v_V	u_L		u_V	h_L		h_V	s_L		s_V
15	53,97	0,001014	10,02218	225,90	2222,83	2448,73	225,91		2599,06	0,7548		8,0084
20	60,06	0,001017	7,64937	251,35	2205,36	2456,71	251,38	2358,33	2609,70	0,8319	7,0766	7,9085
25	64,97	0,001020	6,20424	271,88	2191,21	2463,08	271,90	2346,29	2618,19	0,8930		7,8313

P[KPa]	T[°C]	$h_L[KJ/Kg]$	$h_v[KJ/Kg]$	$s_L[KJ/Kg.K]$	$s_v[KJ/Kg.K]$
20	60,06	251,38	2609,70	0,8319	7,9085

$$X_2 = \frac{5,7431 - 0,8319}{7,0766} = 0,694$$

$$h_2 = 251,38 + 0,694\,(2358,33) = 1888,074$$



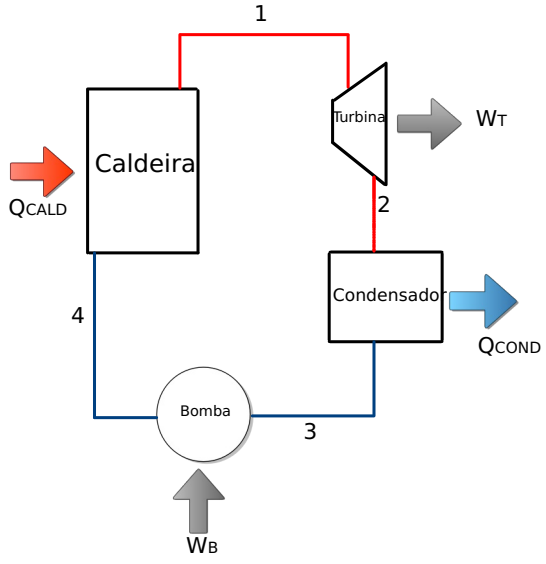


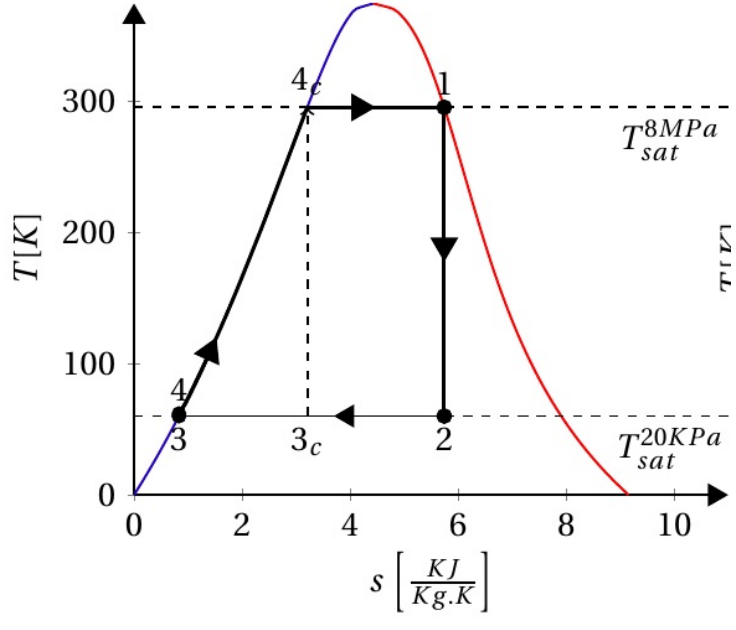
3. Faça uma tabela dos estados

Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	295,06	1	~	2757,94	5,7431
2	20	60,06	x_2	~	1888,074	5,7431
3	20		0	0,001017	251,38	0,8313
4	8000			~		0,8313

15	53,97	[illegible]	10,02218	225,90	2222,83	2448,73	225,91	2373,14	2599,06	0,7548	7,2536	8,0084
20	60,06	0,001017	7,64937	251,35	2205,36	2456,71	251,38	2358,33	2609,70	0,8319	7,0766	7,9085
25	64,97	0,001020	6,20424	271,88	2191,21	2463,08	271,90	2346,29	2618,19	0,8930	6,9383	7,8313

P[KPa]	T[°C]	$h_L[KJ/Kg]$	$h_v[KJ/Kg]$	$s_L[KJ/Kg.K]$	$s_v[KJ/Kg.K]$
20	60,06	251,38	2609,70	0,8319	7,9085





3. Faça uma tabela dos estados

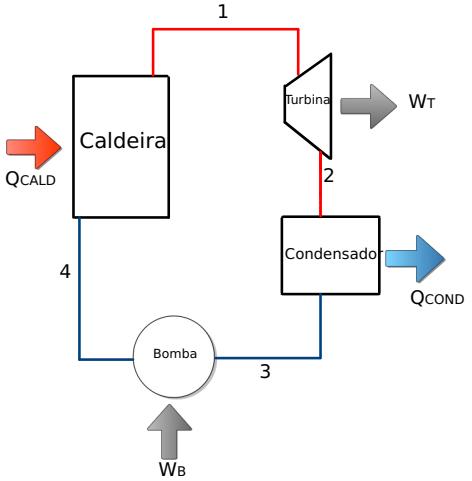
Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	295,06	1	~	2757,94	5,7431
2	20	60,06	x_2	~	1888,074	5,7431
3	20	60,06	0	0,001017	251,38	0,8359
4	8000			~		0,8359

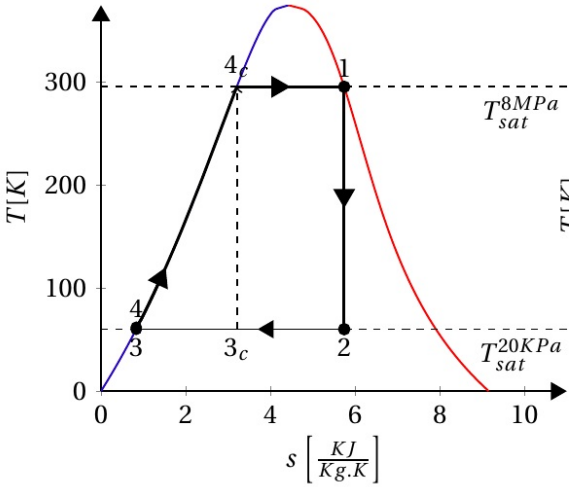
P[KPa]	T[°C]	$h_L[KJ/Kg]$	$h_v[KJ/Kg]$	$s_L[KJ/Kg.K]$	$s_v[KJ/Kg.K]$
8000	295,06	1316,61	2757,94	3,2067	5,7431

$w_b = h_4 - h_3 \simeq v_3(P_4 - P_3)$

$h_4 - 251,38 = 0,001017(8000 - 20)$

$h_4 = 259,49566 \frac{kJ}{kg}$





Ponto 4: temperatura
h_4=259,49566

Água saturada: tabela em função da pressão

		Volume específico (m^3/kg)		Energia interna (kJ/kg)			Entalpia (kJ/kg)			Entropia (kJ/kg K)		
Pressão kPa	Temp. °C	Líquido sat.	Vapor sat.	Líquido sat.	Evap.	Vapor sat.	Líquido sat.	Evap.	Vapor sat.	Líquido sat.	Evap.	Vapor sat.
P	T	v_l	v_v	u_l	u_{lv}	u_v	h_l	h_{lv}	h_v	s_l	s_{lv}	s_v
0,6113	0,01	0,001000	206,132	0	2375,3	2375,3	0,00	2501,30	2501,30	0,0000	9,1562	9,1562
1	6,98	0,001000	129,20802	29,29	2355,69	2384,98	29,29	2484,89	2514,18	0,1059	8,8697	8,9756
1,5	13,03	0,001001	87,98013	54,70	2338,63	2393,32	54,70	2470,59	2525,30	0,1956	8,6322	8,8278
2	17,50	0,001001	67,00385	73,47	2326,02	2399,48	73,47	2460,02	2533,49	0,2607	8,4629	8,7236
2,5	21,08	0,001002	54,25385	88,47	2315,93	2404,40	88,47	2451,56	2540,03	0,3120	8,3311	8,6431
3	24,08	0,001003	45,66502	101,03	2307,48	2408,51	101,03	2444,47	2545,50	0,3545	8,2231	8,5775
4	28,96	0,001004	34,80015	121,44	2293,73	2415,17	121,44	2432,93	2554,37	0,4226	8,0520	8,4746
5	32,88	0,001005	28,19251	137,79	2282,70	2420,49	137,79	2423,66	2561,45	0,4763	7,9187	8,3950
7,5	40,29	0,001008	19,23775	168,76	2261,74	2430,50	168,77	2406,02	2574,79	0,5763	7,6751	8,2514
10	45,81	0,001010	14,67355	191,79	2246,10	2437,89	191,81	2392,82	2584,63	0,6492	7,5010	8,1501
15	53,97	0,001014	10,02218	225,90	2222,83	2448,73	225,91	2373,14	2599,06	0,7548	7,2536	8,0084
20	60,06	0,001017	7,64937	251,35	2205,36	2456,71	251,38	2358,33	2609,70	0,8319	7,0766	7,9085
25	64,97	0,001020	6,20424	271,88	2191,21	2463,08	271,90	2346,29	2618,19	0,8930	6,9383	7,8313
30	69,10	0,001022	5,22918	289,18	2179,22	2468,40	289,21	2336,07	2625,28	0,9439	6,8247	7,7686
40	75,87	0,001026	3,99345	317,51	2159,49	2477,00	317,55	2319,19	2636,74	1,0258	6,6441	7,6700

T	h_L
60,06	$251,38$
T_4	259,49566
64,97	$271,9$

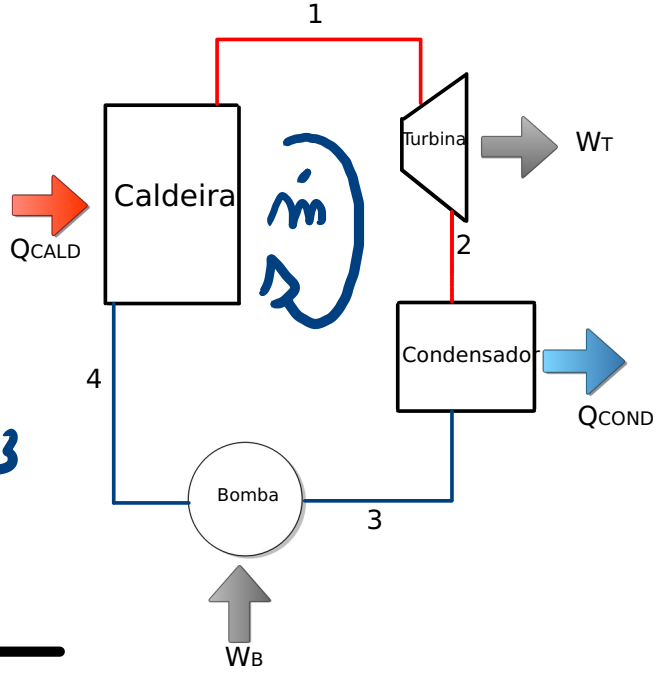
Logo: $T_4 = 62,00[C]$

60,06 °C

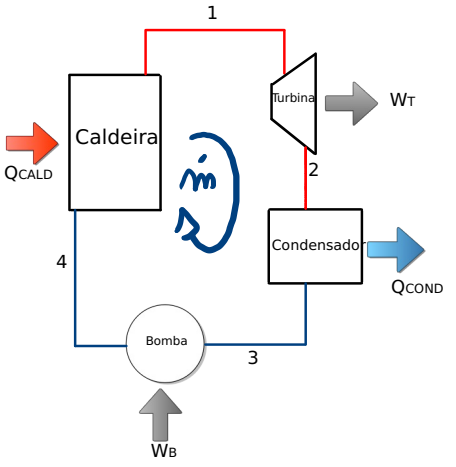
Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	295,06	1	0,2352	2757,94	5,7431
2	20	60,06		0,694	1888,067	5,7431
3	20	60,06	0	0,001017	251,38	0,8319
4	8000	62		0,001017	259,49566	0,8319

$dc = \delta q + \delta w$

Componente	q [kJ/kg]	w [kJ/kg]
CALDEIRA	$h_1 - h_4 = 2438,4434$	0
TURBINA	0	$h_2 - h_1 = -863,873$
CONDENSADOR	$h_3 - h_2 = -1636,687$	0
Bomba	0	$+ 8,11566$
	861,75	-861,75



Componente	q [kJ/kg]	w [kJ/kg]
CALDEIRA	$h_1 - h_4 = 2438,4434$	0
TURBINA	0	$h_2 - h_1 = -863,873$
CONDENSADOR	$h_3 - h_2 = -1636,687$	0
Bomba	0	$+ 8,11566$
	861,75	-863,75



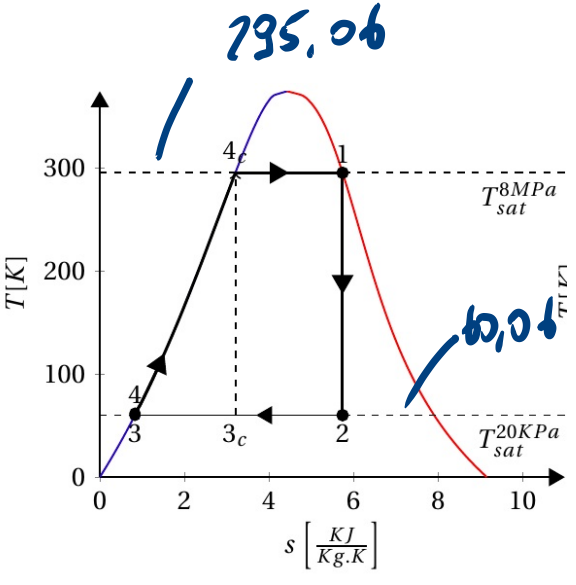
$$\eta = \frac{861,75}{2438,4434} = 0,3448$$

$$bwn = \frac{8,11566}{863,873} = 0,93\%$$

34,48%

$$\eta_C = 1 - \frac{T_F}{T_Q}$$

$\eta_C = 41,35\%$



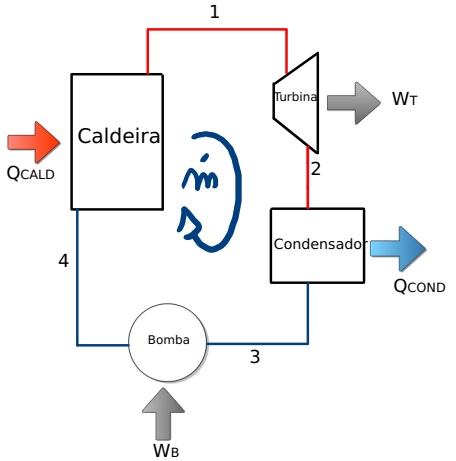
TEMPERATURA MÉDIA DA FONTE QUENTE :

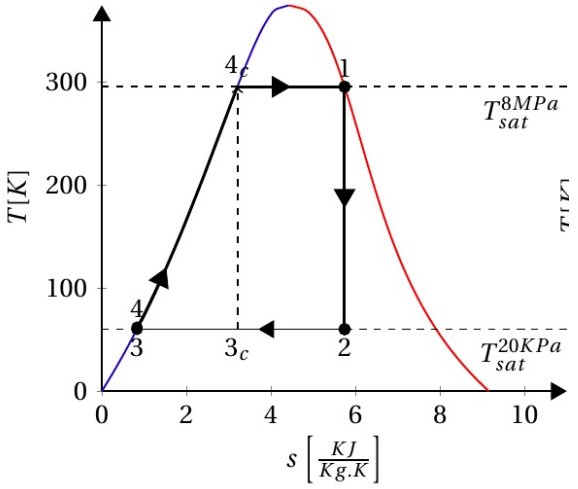
$ds = \frac{\delta q}{T}$

Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	295,06	1	0,2352	2757,94	5,7431
2	20	60,06		0,694	1888,067	5,7431
3	20	60,06	0	0,001017	251,38	0,8319
4	8000	62		0,001017	259,49566	0,8319

$$T_f = \frac{\Delta h}{\Delta s} = \frac{2498,4434\ kJ/kg}{5,7431 - 0,8319\ kJ/kg.K}$$

$$T_f = 508,7236K = 235,56°C \quad (295,06)$$





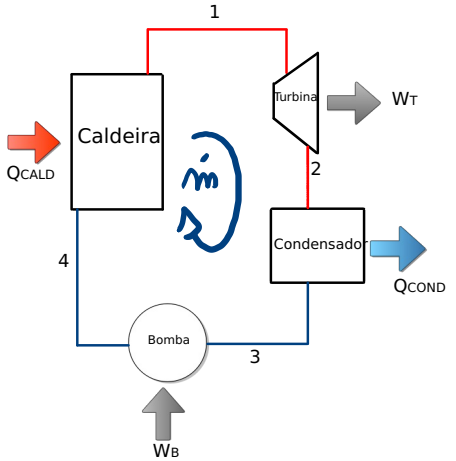
TEMPERATURA MÉDIA DA FONTE QUENTE :

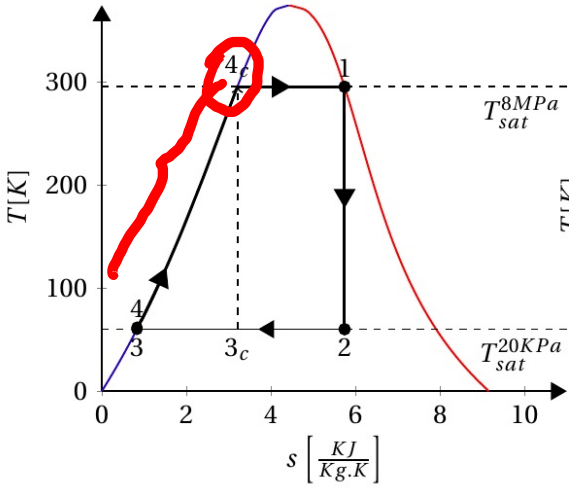
$$ds = \frac{\delta q}{T}$$

Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	295,06	1	0,2352	2757,94	5,7431
2	20	60,06		0,694	1888,067	5,7431
3	20	60,06	0	0,001017	251,38	0,8319
4	8000	62		0,001017	259,49566	0,8319

$$T_f = \frac{q_{23}}{ds_f} = \frac{2498,4434\ kJ/kg}{5,7431 - 0,8319\ kJ/kg.K}$$

$$T_f = 508,7236K = 235,56°C \quad (295,06)$$





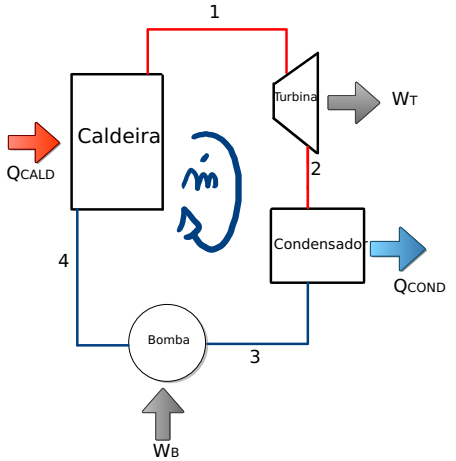
TEMPERATURA MÉDIA DA FONTE FRIA

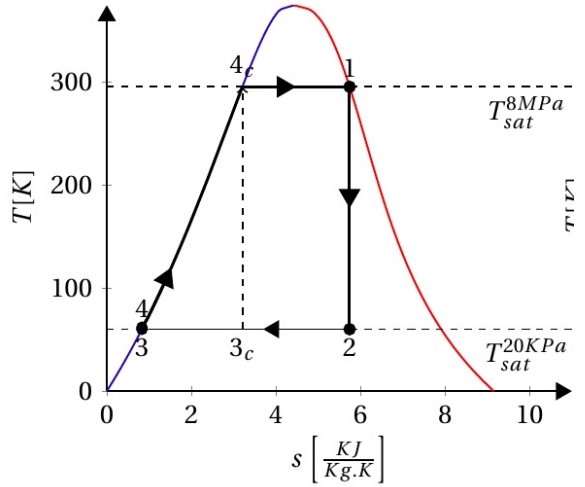
Estado	P[KPa]	T[°C]	x	v[m^3/Kg]	h[KJ/Kg]	s[KJ/Kg.K]
1	8000	295,06	1	0,2352	2757,94	5,7431
2	20	60,06		0,694	1888,067	5,7431
3	20	60,06	0	0,001017	251,38	0,8319
4	8000	62		0,001017	259,49566	0,8319

$$T_F = \frac{q_F}{ds_F} = \frac{-1636,687\ KJ/Kg}{0,8313 - 5,7431\ KJ/Kg\,K}$$

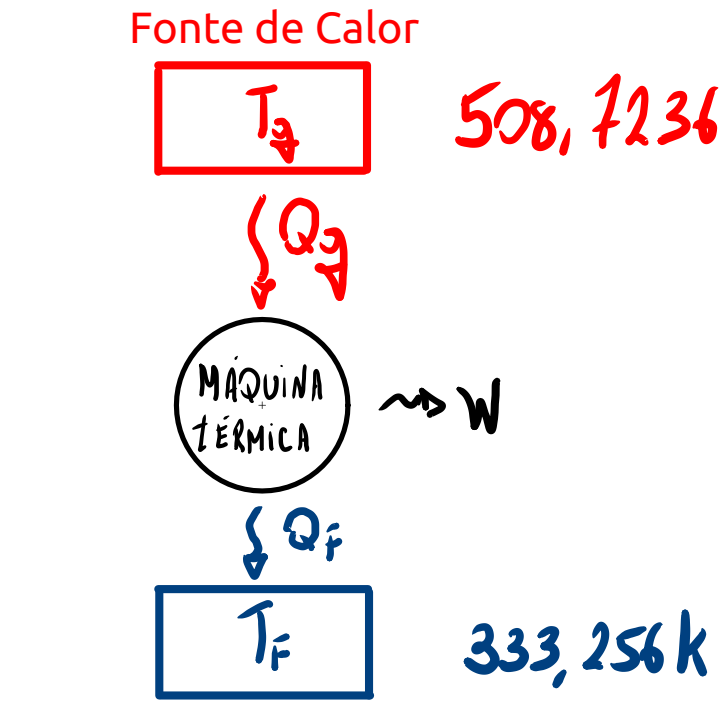
$$T_F = 333,256\ K = 60,096\ °C$$

$$ds = \frac{\delta q}{T}$$





Rendimento máximo DE RANKINE IDEAL



$$\eta = 1 - \frac{333,256}{508,7236}$$

$$\eta = 0,3449$$

mesmo VALOR!!

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