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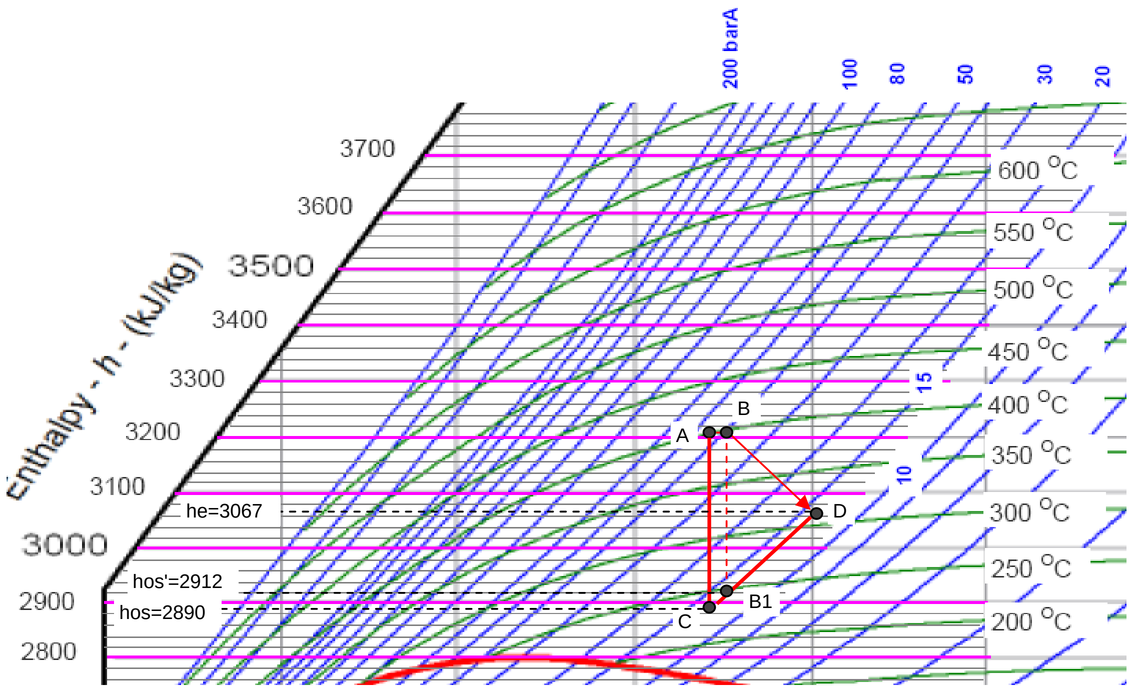
STEAM TURBINE CALCULATION SHEET

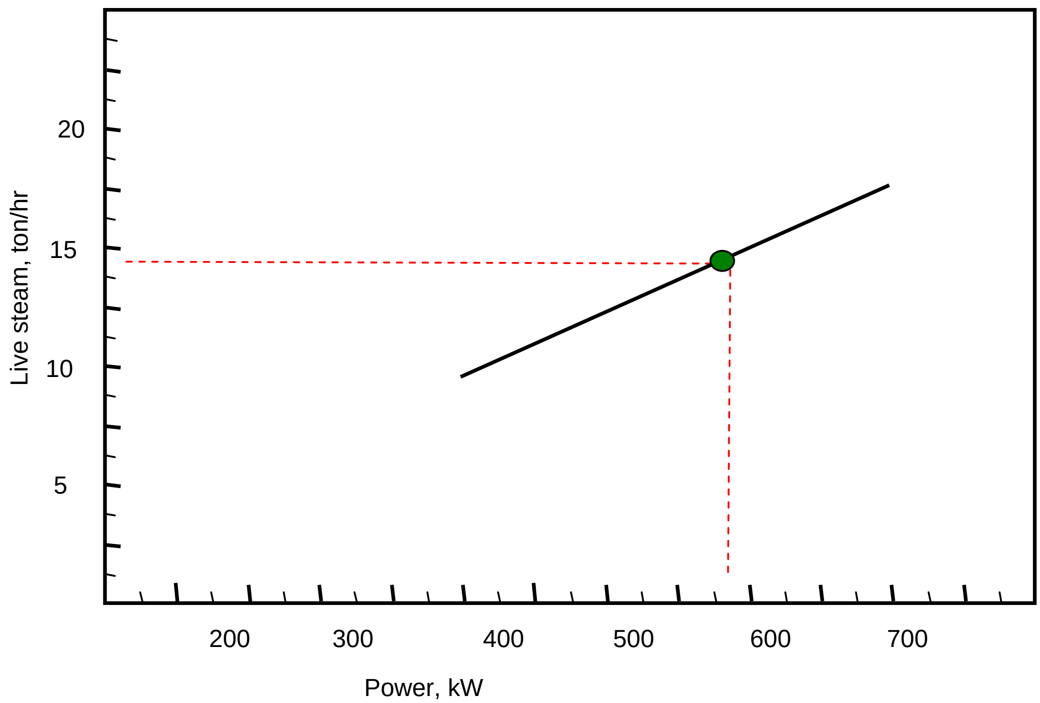
STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1					
2	Turbine type, figure 3		CURTIS		
3					
4	REQUIRED CONDITION				
5					
6	P	kW	535		
7	N	RPM	4000		
8	pi	bar A	42		
9	ti	C	400		
10	po	bar A	13		
11					
12	STEAM DATA				
13					
14	hi	kJ/kg	3210		See steam Mollier diagram
15	hos	kJ/kg	2890		See steam Mollier diagram
16	Δhs	kJ/kg	320		= hi - hos
17	Governor valve factor		0.93		Multi valve 0.97, single valve 0.93
18	Δhs'	kJ/kg	297.6		= Gov. vlv. Factor x Δhs (equation 11)
19	hos'	kJ/kg	2912.4		
20	pi'	bar A	38		
21	ti'	C	395		
22	vi'	m^3/kg	0.077		See steam table at pi' and ti'
23					
24	CALCULATION				
25					
26	Nominal diameter, D	mm	800		See figure 9. Nearest cross point RPM vs Δhs'
27	Peripheral velocity, U	m/s	167.84		Equation 1
28	Head coefficient, μ_S		10.564		Equation 4
29	Efficiency, η_{05}		0.66		Figure 12
30	Entrance area factor, A		34		
31	l x ε	mm	0.447		Equation 15
32	Nozzle height, l	mm	25.0		
33	Degree of admission, ε		0.018		0.015 - 0.45 for welded, min. 0.07 reaming
34	Efficiency factor Fl		0.93		Figure 13
35	Efficiency factor Fe		0.792		Equation in figure 13
36	Efficiency, η_1		0.49		= η_{05} x F_l x Fε
37	Δhe	kJ/kg	144.5		= η_1 x Δhs'
38	he	kJ/kg	3065.5		Than make steam process in Mollier diagr.
39	Exhaust temperature, to	C	305		See steam Mollier diagram
40	Exhaust specific volume, vo	m^3/kg	0.19936		See steam table
41	P_{LOSS}	kW	27.09		Equation 5
42	Mechanical efficiency, η_m		0.956		Figure 15
43	Turbine efficiency, η		0.46		= η_1 x η_m
44	Steam mass flow required, m	ton/hr	14.65		Equation 9
45					
46					
47					
48					
49					



Making steam process :

1. Draw vertical line down from A to B
2. Make point B1 with hos' at pi
3. Draw vertical line from B1 and horizontal line from A. B is the cross point
4. Make point D with he at pi


20
15
10
5
Live steam, ton/hr
200
300
400
500
600
700
Power, kW

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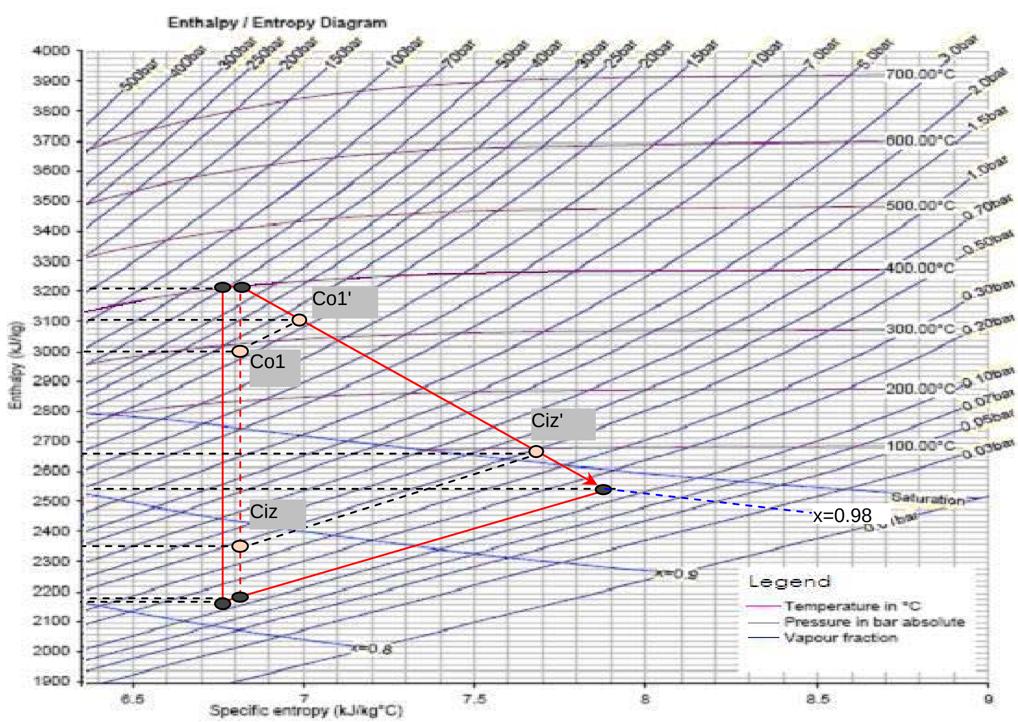
STEAM TURBINE CALCULATION SHEET

STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1					
2	Turbine type, figure 3		RATEAU STAGES		
3			CONDENSING TURBINE		
4	REQUIRED CONDITION				
5					
6	Driven equipment		Syngas Compressor		
7	P	kW	5780		
8	N	RPM	10200		
9	pi	bar A	40		
10	ti	C	400		
11	po	bar A	0.12		
12					
13	STEAM DATA				
14	hi	kJ/kg	3205		See steam Mollier diagram
15	hos	kJ/kg	2160		See steam Mollier diagram
16	Δhs	kJ/kg	1045		= hi - hos
17	Governor valve factor		0.97		Multi valve 0.97, single valve 0.93
18	Δhs'	kJ/kg	1013.65		= Gov. vlv. Factor x Δhs (equation 11)
19	hos'	kJ/kg	2191.35		
20	pi'	bar A	36		
21	ti'	C	395		At hi and pi' (point B)
22	vi'	m^3/kg	0.081		See steam table at pi' and ti' (point B) or
23					extrapolate in steam table
24	CALCULATION				
25	Nominal diameter, D	mm	500		Figure 10. Nearest cross point RPM vs red dot line
26	Calculated number of stages, z1		6.04		
27	Min. no. of stages, zmin		4.95		
28	Taken no. of stages, z		6		Integer
29	Enthalpy per stage, Δh_{STG}	kJ/kg	168.9		= Δhs' / z
30	Power/stage, P_{STG}	kW	963.3		= P / z
31	Peripheral velocity, U	m/s	267.5		Equation 1
32	Head coefficient, μ_S		2.36		Equation 4
33	Efficiency, η_{05}		0.75		Figure 12
34	Entrance area factor, A		34		
35	***First stage***				
36	l x ε	mm	2.787		Equation 15
37	Nozzle height, l	mm	25		Fill with adjustment
38	Degree of admission, ε		0.111		Max. 0.9 for Rateau turbine, fig. 16
39	Efficiency factor F_l		0.95		Figure 13
40	Efficiency factor Fε		0.922		Equation in figure 13
41	Efficiency, η_1		0.66		= η_{05} x F_l x Fε
42	hos_1	kJ/kg	3036.06		Make point at steam chart, Co1
43	Δh_{STG-1}	kJ/kg	111.03		
44	he_{STG-1}	kJ/kg	3093.97		Make point at steam chart, Co1'
45	po_1	bar A	16.0		See steam chart
46	to_1	C	325.0		
47	vo_1	m^3/kg	0.167		See steam table
48	P_{LOSS-1}	kW	70.81		Equation 5

1					
2	***Last stage***				
3	Δhe	kJ/kg	666.2		= η x Δhs' (preliminary eff. = 1'stg eff.)
4	he	kJ/kg	2538.8		Than make steam process in Mollier diagr.
5	hi_{STG-Z}	kJ/kg	2649.9		Make points at steam chart, Ciz and Ciz'
6	pi_1	bar A	0.4		See chart, p and t at point Ciz'
7	ti_1	C	90.0		
8	vi_1	m^3/kg	3.66		
9	Entrance area factor, A		43		
10	l x ε	mm	99.576		
11	Nozzle height, l	mm	110		
12	Degree of admission, ε		0.905		Max. 0.9 for Rateau turbine, fig. 16
13	Efficiency factor F_l		1.00		
14	Efficiency factor $F\varepsilon$		1.00		
15	Efficiency, η_Z		0.75		
16	Vapor partial, X		0.980		
17	Exhaust temperature, to	C	48.7		See steam Mollier diagram
18	Exhaust specific volume, vo	m^3/kg	13.02		See steam table
19	P_{LOSS-Z}	kW	0.47		Equation 5
20	***Average and Total***				
21	Total losses, P_{LOSS}	kW	213.86		
22	Average efficiency, η_{AVG}		0.70		
23	Wet eficiency, η_{WET}		0.9997		
24	Mechanical efficiency, η_m		0.985		Figure 15
25	Turbine efficiency, η		0.69		= η_{AVG} x η_m x η_{WET}
26	Steam mass flow required, m	ton/hr	30.73		Equation 9

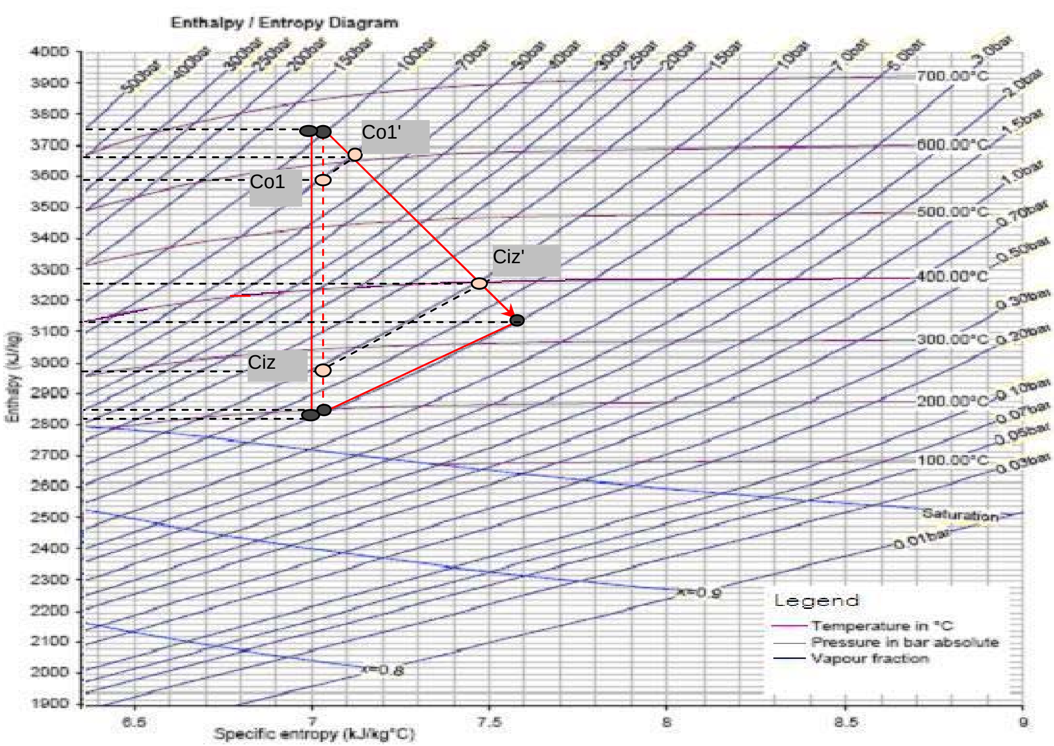


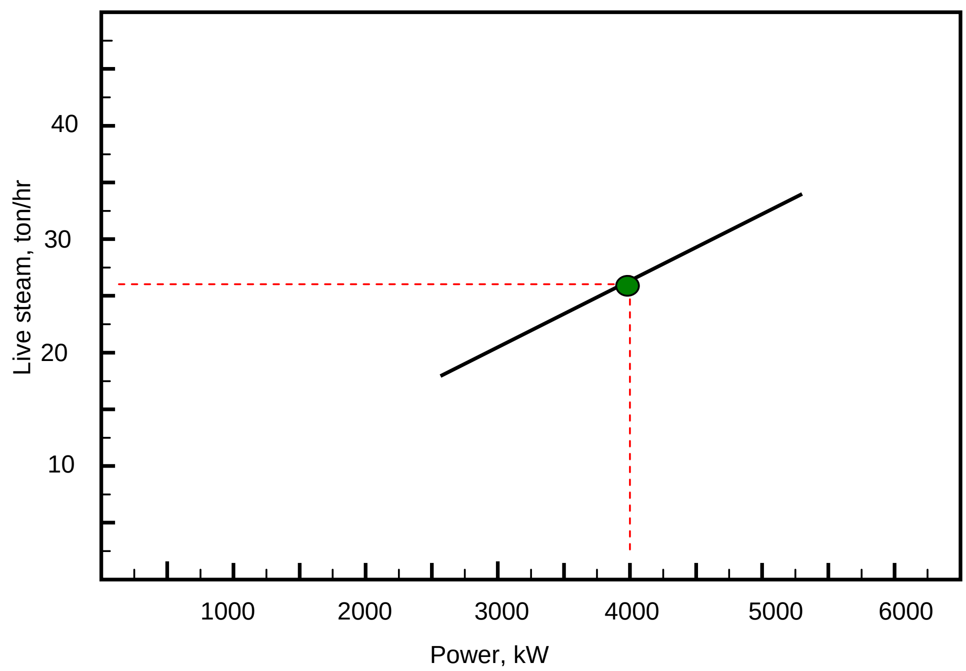
STEAM TURBINE CALCULATION SHEET

STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1					
2	Turbine type, figure 3		RATEAU STAGES		
3			BACK PRESSURE TRUBINE		
4	REQUIRED CONDITION				
5					
6	Driven equipment		Air Compressor		
7	P	kW	4000		
8	N	RPM	9000		
9	pi	bar A	110		
10	ti	C	650		
11	po	bar A	5		
12					
13	STEAM DATA				
14	hi	kJ/kg	3737		See steam Mollier diagram
15	hos	kJ/kg	2820		See steam Mollier diagram
16	Δhs	kJ/kg	917		= hi - hos
17	Governor valve factor		0.97		Multi valve 0.97, single valve 0.93
18	Δhs'	kJ/kg	889.49		= Gov. vlv. Factor x Δhs (equation 11)
19	hos'	kJ/kg	2847.51		
20	pi'	bar A	100		
21	ti'	C	645		At hi and pi' (point B)
22	vi'	m^3/kg	0.0408		See steam table at pi' and ti' (point B) or
23					extrapolate in steam table
24	CALCULATION				
25	Nominal diameter, D	mm	500		Figure 10. Nearest cross point RPM vs red dot line
26	Number of stages, z1		6.81		
27	Min. no. of stages, zmin		2.60		
28	Taken no. of stages, z		7		Integer
29	Enthalpy per stage, Δh_{STG}	kJ/kg	127.1		= Δhs' / z
30	Power/stage, P_{STG}	kW	571.4		= P / z
31	Peripheral velocity, U	m/s	236.0		Equation 1
32	Head coefficient, μ_S		2.28		Equation 4
33	Efficiency, η_{05}		0.82		Figure 12
34	Entrance area factor, A		34		
35	***First stage***				
36	l x ε	mm	1.170		Equation 15
37	Nozzle height, l	mm	25		Fill with adjustment
38	Degree of admission, ε		0.047		Max. 0.9. See fig. 16
39	Efficiency factor F_l		0.97		Figure 13
40	Efficiency factor Fε		0.900		Equation in figure 13
41	Efficiency, η_1		0.71		= η_{05} x F_l x Fε
42	hos_1	kJ/kg	3609.93		Make point at steam chart, Co1
43	Δh_{STG-1}	kJ/kg	90.81		
44	he_{STG-1}	kJ/kg	3646.19		Make point at steam chart, Co1'
45	po_1	bar A	69.0		See steam chart
46	to_1	C	610.0		
47	vo_1	m^3/kg	0.057		See steam table
48	P_{LOSS-1}	kW	151.31		Equation 5

1					
2	***Last stage***				
3	Δhe	kJ/kg	635.7		= η x Δhs' (preliminary eff. = 1'stg eff.)
4	he	kJ/kg	3101.3		Than make steam process in Mollier diagr.
5	hi_{STG-Z}	kJ/kg	3192.2		Make points at steam chart, Ciz and Ciz'
6	pi_1	bar A	9.5		See chart, p and t at point Ciz'
7	ti_1	C	400.0		
8	vi_1	m^3/kg	0.32		
9	Entrance area factor, A		43		
10	l x ε	mm	7.339		
11	Nozzle height, l	mm	25		
12	Degree of admission, ε		0.294		
13	Efficiency factor F_l		0.97		
14	Efficiency factor Fε		0.97		
15	Efficiency, η_Z		0.77		
16	Vapor partial, X		0.00		Fill with 0 (zero) for back pressure turbine.
17	Exhaust temperature, to	C	330		See steam Mollier diagram
18	Exhaust specific volume, vo	m^3/kg	0.553		See steam table
19	P_{LOSS-Z}	kW	11.98		Equation 5
20	***Average and Total***				
21	Total losses, P_{LOSS}	kW	571.53		
22	Average efficiency, η_{AVG}		0.74		
23	Wet eficiency, η_{WET}		1.00		
24	Mechanical efficiency, η_m		0.971		Figure 15
25	Turbine efficiency, η		0.72		= η_{AVG} x η_m x η_{WET}
26	Steam mass flow required, m	ton/hr	25.68		Equation 9




40
30
20
10
Live steam, ton/hr
1000
2000
3000
4000
5000
6000
Power, kW