

Software Information

General information

TESPy Version:	0.4.3-005 - Grassmann's Graph
Commit:	84386adc@dev
CoolProp version:	6.4.0
Python version:	3.8.0 (default, Oct 28 2019, 16:14:01) [GCC 8.3.0]
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Parameter highlighting

Variable component parameters:	<i>italic</i>
Specified input parameter:	bold
Results of simulation:	normalfont

Equations are displayed for input parameters only.

1 Connections in design mode

1.1 Connection specifications and results

Table 1: Connection specifications and results

label	m in kg/s (1)	p in bar (2)	h in kJ/kg	T in °C (3)	s in kJ/kgK	x in – (4)	Td.bp in °C (5)
1	38.969	100.0000	3,002.40	371.0	6.0697	-1.00	-
2	38.969	100.0000	3,002.40	371.0	6.0697	-1.00	-
3	38.969	33.6100	2,804.82	240.7	6.1443	-1.00	-
4	36.012	33.6100	2,804.82	240.7	6.1443	-1.00	-
5	36.012	18.5800	2,707.54	208.7	6.1810	0.95	-
6	33.524	18.5800	2,707.54	208.7	6.1810	0.95	-
7	33.524	17.1000	3,189.77	371.0	7.1106	-1.00	-
8	33.524	7.9800	3,015.17	280.3	7.1616	-1.00	-
9	31.041	7.9800	3,015.17	280.3	7.1616	-1.00	-
10	31.041	2.7300	2,797.89	166.4	7.2068	-1.00	-
11	29.273	2.7300	2,797.89	166.4	7.2068	-1.00	-
12	29.273	0.9600	2,623.62	98.5	7.2393	0.98	-
13	27.676	0.9600	2,623.62	98.5	7.2393	0.98	-
14	27.676	0.2900	2,461.05	68.3	7.3042	0.93	-
15	26.568	0.2900	2,461.05	68.3	7.3042	0.93	-
16	26.568	0.0800	2,348.06	41.5	7.5023	0.91	-
17	31.041	0.0800	2,040.95	41.5	6.5263	0.78	-
18	31.041	0.0800	173.84	41.5	0.5925	0.00	-
19	31.041	14.7550	175.95	41.7	0.5945	-1.00	-
20	31.041	14.7550	185.97	44.1	0.6262	-1.00	-
21	31.041	9.9975	265.88	63.3	0.8722	-1.00	-
22	31.041	9.9975	277.34	66.1	0.9061	-1.00	-
23	31.041	8.7012	392.25	93.5	1.2323	-1.00	-
24	31.041	8.7012	398.73	95.0	1.2499	-1.00	-
25	31.041	7.9800	526.89	125.3	1.5846	-1.00	-
26	38.969	7.9800	720.41	170.3	2.0446	0.00	-
31	38.969	103.5600	1,016.11	235.2	2.6433	-1.00	-
32	38.969	103.4200	1,410.39	311.5	3.3638	-1.00	-2.0
33	78.680	103.4200	1,422.74	313.5	3.3849	0.00	-
34	78.680	103.4200	2,070.94	313.5	4.4898	0.50	-
35	38.969	103.4200	2,719.14	313.5	5.5948	1.00	-
36	2.957	33.6100	2,804.82	240.7	6.1443	-1.00	-
39	2.957	18.5800	914.90	208.7	2.4605	0.01	-
40	2.489	18.5800	2,707.54	208.7	6.1810	0.95	-
41	5.445	18.5800	1,734.16	208.7	4.1608	0.44	-
44	5.445	7.9800	777.12	170.3	2.1725	0.03	-
45	2.483	7.9800	3,015.17	280.3	7.1616	-1.00	-
46	1.768	2.7300	2,797.89	166.4	7.2068	-1.00	-
47	1.768	2.7300	547.81	130.3	1.6382	0.00	-
48	1.768	2.7300	433.92	103.5	1.3461	-1.00	-
49	1.768	0.9600	433.92	98.5	1.3470	0.01	-
50	1.596	0.9600	2,623.62	98.5	7.2393	0.98	-
51	3.364	0.9600	1,472.90	98.5	4.1428	0.47	-
52	3.364	0.9600	412.71	98.5	1.2899	-0.00	-
53	3.364	0.9600	307.02	73.3	0.9954	-1.00	-
54	3.364	0.2900	307.02	68.3	0.9961	0.01	-

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Table 1: Connection specifications and results

label	m in kg/s (1)	p in bar (2)	h in kJ/kg	T in °C (3)	s in kJ/kgK	x in – (4)	Td.bp in °C (5)
55	1.108	0.2900	2,461.05	68.3	7.3042	0.93	-
56	4.472	0.2900	840.68	68.3	2.5589	0.24	-
57	4.472	0.2900	286.02	68.3	0.9345	-0.00	-
58	4.472	0.2900	216.49	51.7	0.7258	-1.00	-
59	4.472	0.0800	216.49	41.5	0.7280	0.02	-
60	2,132.083	1.0663	153.03	36.5	0.5255	-1.00	-
61	2,132.083	1.0663	153.03	36.5	0.5255	-1.00	-
62	2,132.083	1.0130	125.82	30.0	0.4367	-1.00	-
63	2,132.083	1.1848	125.85	30.0	0.4367	-1.00	-
64	11,691.521	1.0130	424.44	25.0	3.8806	-1.00	-
65	11,691.521	1.0135	424.51	25.1	3.8807	-1.00	-
66	11,691.521	1.0130	429.47	30.0	3.8973	-1.00	-
67	405.389	23.3040	761.43	390.0	1.6201	-inf	-
68	405.389	23.3040	761.43	390.0	1.6201	-inf	-
69	353.337	23.3040	761.43	390.0	1.6201	-inf	-
70	353.337	22.7530	730.18	377.7	1.5726	-inf	-
71	353.337	21.1670	585.85	318.5	1.3406	-inf	-
72	353.337	20.3400	542.36	299.8	1.2661	-inf	-
73	52.052	23.3040	761.43	390.0	1.6201	-inf	-
74	52.052	20.3400	450.85	259.2	1.1005	-inf	-
75	405.389	20.3400	530.61	294.7	1.2455	-inf	-
76	405.389	41.0240	534.80	296.3	1.2484	-inf	-
27	38.969	125.0000	738.98	173.1	2.0571	-1.00	-
28	38.969	125.0000	754.98	176.8	2.0928	-1.00	-
29	38.969	112.0000	872.71	203.7	2.3501	-1.00	-
30	38.969	112.0000	882.11	205.8	2.3698	-1.00	-
37	2.957	33.6100	1,038.69	240.2	2.7042	0.00	-
38	2.957	33.6100	914.90	213.7	2.4566	-1.00	-
42	5.445	18.5800	891.63	208.7	2.4122	0.00	-
43	5.445	18.5800	777.12	183.1	2.1681	-1.00	-

1.2 Equations applied

$$0 = \dot{m} - \dot{m}_{\text{spec}} \quad (1)$$

$$0 = p - p_{\text{spec}} \quad (2)$$

$$0 = T(p, h) - T_{\text{spec}} \quad (3)$$

$$0 = h - h(p, x_{\text{spec}}) \quad (4)$$

$$0 = \Delta T_{\text{spec}} - T_{\text{sat}}(p) \quad (5)$$

1.3 Specified fluids

Table 2: Specified fluids			
	TVP1 (6)	air (7)	water (8)
label			
1	0.000	0.000	1.000
62	0.000	0.000	1.000
64	0.000	1.000	0.000
67	1.000	0.000	0.000

1.4 Equations applied

$$0 = x_{\text{TVP1}} - x_{\text{TVP1,spec}} \quad (6)$$

$$0 = x_{\text{air}} - x_{\text{air,spec}} \quad (7)$$

$$0 = x_{\text{water}} - x_{\text{water,spec}} \quad (8)$$

1.5 Referenced mass flow

Table 3: Specified reference values for mass flow

	reference	factor in -	delta in kg/s
label			
0	67	0.1284	0

1.6 Equation applied

$$0 = \text{value} - \text{value}_{\text{ref}} \cdot \text{factor} + \text{delta} \quad (9)$$

2 Components in design mode

2.1 Components of type HeatExchanger

2.1.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \quad \forall i \in [1, 2] \quad (10)$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \quad \forall fl \in \text{network fluids}, \forall i \in [1, 2] \quad (11)$$

$$0 = \dot{m}_{\text{in},1} \cdot (h_{\text{out},1} - h_{\text{in},1}) + \dot{m}_{\text{in},2} \cdot (h_{\text{out},2} - h_{\text{in},2}) \quad (12)$$

2.1.2 Specifications and results

Table 4: Parameters of components of type HeatExchanger

label	Q	ttd_u	ttd_l (13)	pr1 (14)	pr2 (15)
Superheater	-11,038,645.89	19.00	64.21	0.98	0.97
Reheater	-16,165,997.53	19.00	50.50	0.87	0.92
Low pressure preheater 1 subcooling	-310,958.68	24.21	10.00	1.00	1.00
Low pressure preheater 2 subcooling	-355,547.41	32.41	10.00	1.00	1.00
Low pressure preheater 3 subcooling	-201,352.32	35.32	10.00	1.00	1.00
Economizer	-15,364,788.65	7.00	64.59	0.96	1.00
Evaporator	-51,000,483.02	64.21	5.00	0.93	1.00
Cooling tower	-58,008,902.88	6.51	4.93	0.95	1.00
High pressure preheater 1 subcooling	-623,547.56	31.90	10.00	1.00	1.00
High pressure preheater 2 subcooling	-366,012.28	34.45	10.00	1.00	1.00

2.1.3 Equations applied

$$0 = ttd_l - T_{out,1} + T_{in,2} \quad (13)$$

$$0 = p_{in,1} \cdot pr1 - p_{out,1} \quad (14)$$

$$0 = p_{in,2} \cdot pr2 - p_{out,2} \quad (15)$$

2.2 Components of type CycleCloser

2.2.1 Mandatory constraints

$$0 = p_{in,i} - p_{out,i} \quad \forall i \in [1] \quad (16)$$

$$0 = h_{in,i} - h_{out,i} \quad \forall i \in [1] \quad (17)$$

2.3 Components of type Turbine

2.3.1 Mandatory constraints

$$0 = \dot{m}_{in,i} - \dot{m}_{out,i} \quad \forall i \in [1] \quad (18)$$

$$0 = x_{fl,in,i} - x_{fl,out,i} \quad \forall fl \in \text{network fluids}, \forall i \in [1] \quad (19)$$

2.3.2 Specifications and results

Table 5: Parameters of components of type Turbine

label	P	eta_s (20)	pr
HP turbine 1	-7,699,459.42	0.84	0.34
HP turbine 2	-3,503,353.54	0.85	0.55
LP turbine 1	-5,853,157.76	0.86	0.47
LP turbine 2	-6,744,442.54	0.92	0.34
LP turbine 3	-5,101,417.76	0.94	0.35
LP turbine 4	-4,499,249.42	0.88	0.30
LP turbine 5	-3,001,919.77	0.64	0.28

2.3.3 Equations applied

$$0 = -(h_{\text{out}} - h_{\text{in}}) + (h_{\text{out},s} - h_{\text{in}}) \cdot \eta_s \quad (20)$$

2.4 Components of type Splitter

2.4.1 Mandatory constraints

$$0 = \sum \dot{m}_{\text{in},i} - \sum \dot{m}_{\text{out},j} \quad \forall i \in \text{inlets}, \forall j \in \text{outlets} \quad (21)$$

$$0 = x_{fl,\text{in}} - x_{fl,\text{out},j} \quad \forall fl \in \text{network fluids}, \forall j \in \text{outlets} \quad (22)$$

$$0 = h_{\text{in}} - h_{\text{out},j} \quad \forall j \in \text{outlets} \quad (23)$$

$$\begin{aligned} 0 &= p_{\text{in},1} - p_{\text{in},i} \quad \forall i \in \text{inlets} \setminus \{1\} \\ 0 &= p_{\text{in},1} - p_{\text{out},j} \quad \forall j \in \text{outlets} \end{aligned} \quad (24)$$

2.5 Components of type Merge

2.5.1 Mandatory constraints

$$0 = \sum \dot{m}_{\text{in},i} - \sum \dot{m}_{\text{out},j} \quad \forall i \in \text{inlets}, \forall j \in \text{outlets} \quad (25)$$

$$0 = \sum_i \dot{m}_{\text{in},i} \cdot x_{fl,\text{in},i} - \dot{m}_{\text{out}} \cdot x_{fl,\text{out}} \quad \forall fl \in \text{network fluids}, \forall i \in \text{inlets} \quad (26)$$

$$0 = \sum_i (\dot{m}_{\text{in},i} \cdot h_{\text{in},i}) - \dot{m}_{\text{out}} \cdot h_{\text{out}} \quad \forall i \in \text{inlets} \quad (27)$$

$$\begin{aligned} 0 &= p_{\text{in},1} - p_{\text{in},i} \quad \forall i \in \text{inlets} \setminus \{1\} \\ 0 &= p_{\text{in},1} - p_{\text{out},j} \quad \forall j \in \text{outlets} \end{aligned} \quad (28)$$

2.6 Components of type Condenser

2.6.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \quad \forall i \in [1, 2] \quad (29)$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \quad \forall fl \in \text{network fluids}, \forall i \in [1, 2] \quad (30)$$

$$0 = \dot{m}_{\text{in},1} \cdot (h_{\text{out},1} - h_{\text{in},1}) + \dot{m}_{\text{in},2} \cdot (h_{\text{out},2} - h_{\text{in},2}) \quad (31)$$

2.6.2 Specifications and results

Table 6: Parameters of components of type Condenser

label	Q	ttd_u (32)	ttd_l	pr1 (33)	pr2 (34)
Condenser	-57,956,348.47	5.00	11.51	1.00	0.90
Low pressure preheater 1	-2,480,570.42	5.00	24.21	1.00	0.68
Low pressure preheater 2	-3,566,757.71	5.00	32.41	1.00	0.87
Low pressure preheater 3	-3,978,057.22	5.00	35.32	1.00	0.92
High pressure preheater 1	-4,587,816.13	5.00	31.90	1.00	0.90
High pressure preheater 2	-5,221,925.04	5.00	34.45	1.00	0.92

2.6.3 Equations applied

$$0 = ttd_u - T_{\text{sat}}(p_{\text{in},1}) + T_{\text{out},2} \quad (32)$$

$$0 = p_{\text{in},1} \cdot pr1 - p_{\text{out},1} \quad (33)$$

$$0 = p_{\text{in},2} \cdot pr2 - p_{\text{out},2} \quad (34)$$

2.7 Components of type Pump

2.7.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \quad \forall i \in [1] \quad (35)$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \quad \forall fl \in \text{network fluids}, \forall i \in [1] \quad (36)$$

2.7.2 Specifications and results

Table 7: Parameters of components of type Pump

label	P	eta_s (37)	pr
Condenser pump	65,605.65	0.70	184.44
Feedwater pump	723,827.94	0.70	15.66
Cooling water pump	52,554.42	0.70	1.17
HTF pump	1,700,238.56	0.60	2.02

2.7.3 Equations applied

$$0 = -(h_{\text{out}} - h_{\text{in}}) \cdot \eta_s + (h_{\text{out},s} - h_{\text{in}}) \quad (37)$$

2.8 Components of type Drum

2.8.1 Mandatory constraints

$$0 = \sum \dot{m}_{\text{in},i} - \sum \dot{m}_{\text{out},j} \quad \forall i \in \text{inlets}, \forall j \in \text{outlets} \quad (38)$$

$$0 = x_{fl,\text{in},1} - x_{fl,\text{out},j} \quad \forall fl \in \text{network fluids}, \forall j \in \text{outlets} \quad (39)$$

$$0 = \sum_i (\dot{m}_{\text{in},i} \cdot h_{\text{in},i}) - \sum_j (\dot{m}_{\text{out},j} \cdot h_{\text{out},j}) \quad \forall i \in \text{inlets} \quad \forall j \in \text{outlets} \quad (40)$$

$$\begin{aligned} 0 &= p_{\text{in},1} - p_{\text{in},i} \quad \forall i \in \text{inlets} \setminus \{1\} \\ 0 &= p_{\text{in},1} - p_{\text{out},j} \quad \forall j \in \text{outlets} \end{aligned} \quad (41)$$

$$\begin{aligned} 0 &= h_{\text{out},1} - h(p_{\text{out},1}, x = 0) \\ 0 &= h_{\text{out},2} - h(p_{\text{out},2}, x = 1) \end{aligned} \quad (42)$$

2.9 Components of type Valve

2.9.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \quad \forall i \in [1] \quad (43)$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \quad \forall fl \in \text{network fluids}, \forall i \in [1] \quad (44)$$

$$0 = h_{\text{in},i} - h_{\text{out},i} \quad \forall i \in [1] \quad (45)$$

2.9.2 Specifications and results

Table 8: Parameters of components of type Valve

	pr	zeta
label		
Valve 1	0.55	116,509,403.93
Valve 2	0.43	9,926,543.49
Valve 3	0.35	7,513,567.89
Valve 4	0.30	288,942.73
Valve 5	0.28	8,013.54

2.10 Components of type Compressor

2.10.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \quad \forall i \in [1] \quad (46)$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \quad \forall fl \in \text{network fluids}, \forall i \in [1] \quad (47)$$

2.10.2 Specifications and results

Table 9: Parameters of components of type Compressor

	P	eta_s (48)	pr
label			
Cooling tower fan	822,719.88	0.60	1.00

2.10.3 Equations applied

$$0 = -(h_{\text{out}} - h_{\text{in}}) \cdot \eta_s + (h_{\text{out},s} - h_{\text{in}}) \quad (48)$$

2.11 Components of type ParabolicTrough

2.11.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \quad \forall i \in [1] \quad (49)$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \quad \forall fl \in \text{network fluids}, \forall i \in [1] \quad (50)$$

2.11.2 Specifications and results

Table 10: Parameters of components of type ParabolicTrough

	Q	pr	zeta	energy_group (51)
label				
Parabolic trough	91,869,676.53	0.57	10,127.07	True

Table 11: Parametergroup energy_group

	E	eta_opt	aoi	doc	c_1	c_2	iam_1	iam_2	A	Tamb
label										
Parabolic trough	1,000.00	0.73	0.00	0.95	0.00	0.00	1.00	1.00	<i>151,993.96</i>	25.00

2.11.3 Equations applied

$$\begin{aligned}
0 &= \dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}}) \\
&\quad - A \cdot [E \cdot \eta_{\text{opt}} \cdot \text{doc}^{1.5} \cdot \text{iam} \\
&\quad - c_1 \cdot (T_{\text{m}} - T_{\text{amb}}) - c_2 \cdot (T_{\text{m}} - T_{\text{amb}})^2] \\
T_{\text{m}} &= \frac{T_{\text{out}} + T_{\text{in}}}{2} \\
\text{iam} &= 1 - \text{iam}_1 \cdot |\text{aoi}| - \text{iam}_2 \cdot \text{aoi}^2
\end{aligned} \tag{51}$$

3 Busses in design mode

3.1 Bus “total output power”

This bus is used for postprocessing only.

Table 12: Results overview for bus total output power

	\dot{E}_{comp}	$\dot{E}_{\text{comp,result}}$	\dot{E}_{bus}	$\dot{E}_{\text{bus,result}}$	η_{result}
label					
HP turbine 1	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	-7,699,459.42	$\dot{E}_{\text{comp}} \cdot \eta$	-7,468,475.64	0.97
HP turbine 2	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	-3,503,353.54	$\dot{E}_{\text{comp}} \cdot \eta$	-3,398,252.93	0.97
LP turbine 1	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	-5,853,157.76	$\dot{E}_{\text{comp}} \cdot \eta$	-5,677,563.03	0.97
LP turbine 2	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	-6,744,442.54	$\dot{E}_{\text{comp}} \cdot \eta$	-6,542,109.27	0.97
LP turbine 3	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	-5,101,417.76	$\dot{E}_{\text{comp}} \cdot \eta$	-4,948,375.22	0.97
LP turbine 4	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	-4,499,249.42	$\dot{E}_{\text{comp}} \cdot \eta$	-4,364,271.94	0.97
LP turbine 5	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	-3,001,919.77	$\dot{E}_{\text{comp}} \cdot \eta$	-2,911,862.18	0.97
Feedwater pump	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	723,827.94	$\frac{\dot{E}_{\text{comp}}}{\eta}$	761,924.15	0.95
Condenser pump	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	65,605.65	$\frac{\dot{E}_{\text{comp}}}{\eta}$	69,058.58	0.95
HTF pump	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	1,700,238.56	$\frac{\dot{E}_{\text{comp}}}{\eta}$	1,789,724.80	0.95
Cooling water pump	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	52,554.42	$\frac{\dot{E}_{\text{comp}}}{\eta}$	55,320.44	0.95
Cooling tower fan	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	822,719.88	$\frac{\dot{E}_{\text{comp}}}{\eta}$	866,020.92	0.95
total	-	-33,038,053.77	-	-31,768,861.31	-

3.2 Bus “heat input”

This bus is used for postprocessing only.

Table 13: Results overview for bus heat input

label		\dot{E}_{comp}	$\dot{E}_{\text{comp,result}}$	\dot{E}_{bus}	$\dot{E}_{\text{bus,result}}$	η_{result}
Parabolic trough	$\dot{m}_{\text{in}} \cdot (h_{\text{out}} - h_{\text{in}})$	91,869,676.53	$\frac{\dot{E}_{\text{comp}}}{\eta}$	91,869,676.53	1.00	
total	-	91,869,676.53	-	91,869,676.53	-	-