ORC and CO2 Organic Rankine Cycle Performance Charts by Infinity Turbine

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https://infinityturbine.com/orc-and-co2-organic-rankine-cycle-performance-charts-by-infinity-turbine.html

Infinity Turbine LLC offers ORC and CO2 Organic Rankine Cycle performance charts for optimizing waste heat to energy conversion. Our Filemaker database application helps calculate the most efficient working fluid for ORC and Rankine Cycle, ensuring the best performance in waste heat recovery.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

Organic Rankine Cycle and SCO2 Performance Curves

PDF Version of running working fluids in Filemaker database app.

Available for purchase.

Organic Rankine Cycle and Supercritical CO2
Performance Curves
2013
R134a • R245fa • CO2

Note:

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Updated
January 7, 2014
2014 Infinity Turbine LLC
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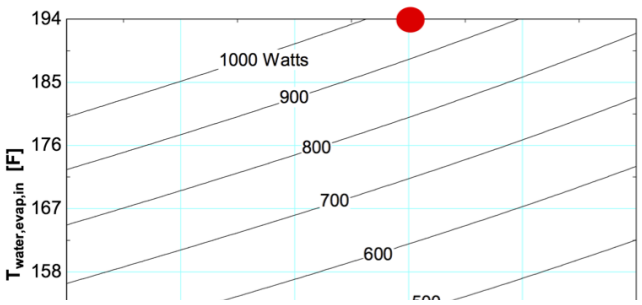
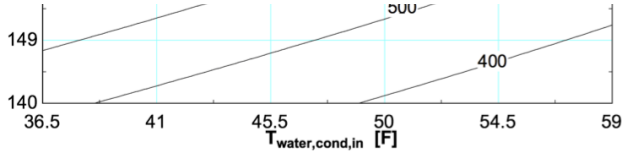
R134a Performance Chart

4 GPM Condenser Water
0.5ft Condenser Width
0.5ft Evaporator Width





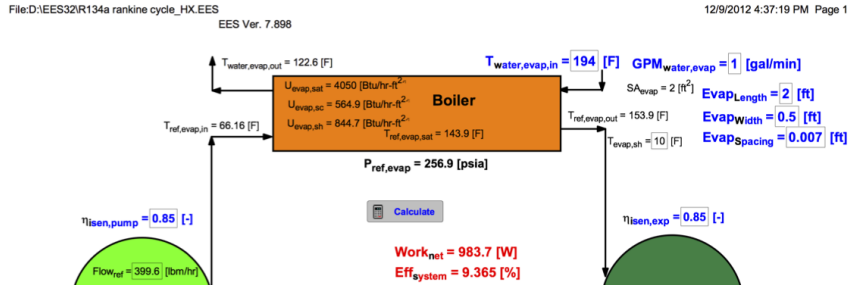
R134a Performance Chart

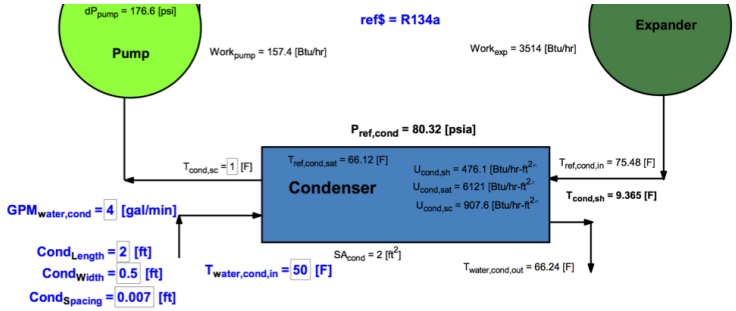
Parametric Table: minmaxtable (copy)

	$Evap_{Width}$ [ft]	$Cond_{Width}$ [ft]	$Flow_{ref}$ [lbm/hr]	$GPM_{water,cond}$ [gal/min]	$T_{water,cond,in}$ [F]	$T_{water,evap,in}$ [F]	$Work_{net}$ [W]	$P_{ref,evap}$ [psia]	$P_{ref,cond}$ [psia]	$T_{water,cond,out}$ [F]	$T_{water,evap,out}$ [F]
Run 1	0.125	0.125	254.5	2	50	194	692.5	582.6	85.64	17.69	148.8
Run 2	0.125	0.25	254.5	2	50	194	696.6	507.7	89.18	113.2	148.7
Run 3	0.125	0.5	291	2	50	194	735.5	166.5	89.63	61.73	142.8
Run 4	0.125	1	291	2	50	194	736.4	321.3	90	64.19	142.8
Run 5	0.125	1.5	291	2	50	194	736.7	187.2	69.98	7.724	142.8
Run 6	0.25	0.125	254.5	2	50	194	702.4	218.5	35.87	7.507	148.7
Run 7	0.25	0.25	254.5	2	50	194	706.4	192.3	40.93	18.21	148.6
Run 8	0.25	0.5	291	2	50	194	749.5	500.2	86.68	50.69	142.7
Run 9	0.25	1	291	2	50	194	750.4	186.9	70.17	77.63	142.7
Run 10	0.25	1.5	291	2	50	194	750.6	118.2	88.54	38.72	142.7
Run 11	0.5	0.125	254.5	2	50	194	706.7	480.7	57.28	29.39	148.7
Run 12	0.5	0.25	254.5	2	50	194	710.8	178.5	36.86	70.57	148.6
Run 13	0.5	0.5	291	2	50	194	756.1	552.6	57.25	28.91	142.7
Run 14	0.5	1	291	2	50	194	756.9	533.4	34.57	175	142.7
Run 15	0.5	1.5	291	2	50	194	757.2	309	89.8	51.1	142.7
Run 16	1	0.125	254.5	2	50	194	708.2	584.1	79.33	25.12	148.7
Run 17	1	0.25	254.5	2	50	194	712.2	583	60.9	49.58	148.6
Run 18	1	0.5	291	2	50	194	758.5	584.5	88.39	13.77	142.7

Run 19	1	1	291	2	50	194	759.3	586.2	88.29	41.19	142.7
Run 20	1	1.5	291	2	50	194	759.6	322	90	65.27	142.7
Run 21	1.5	0.125	254.5	2	50	194	708.5	429.7	88.2	84.98	148.7
Run 22	1.5	0.25	254.5	2	50	194	712.5	466	36.78	110.4	148.6
Run 23	1.5	0.5	291	2	50	194	758.9	91.74	89.99	64.67	142.7
Run 24	1.5	1	291	2	50	194	759.8	410.2	84.68	51.14	142.7
Run 25	1.5	1.5	291	2	50	194	760	324.5	90	63.21	142.7
Run 26	0.5	0.5	239.4	4	50	140	388.3	149.6	71.96	59.9	97.69
Run 27	0.5	0.5	294.4	4	50	158	555.9	177.1	74.78	62.11	105.7
Run 28	0.5	0.5	352.2	4	50	176	754.5	209.8	77.81	64.41	113.3
Run 29	0.5	0.5	399.6	4	50	194	983.7	256.9	80.32	66.24	122.6
Run 30	0.5	0.5	218.8	4	59	140	310.2	157.3	82.79	67.88	102.3
Run 31	0.5	0.5	274	4	59	158	460.8	185.9	85.88	70.07	110.6
Run 32	0.5	0.5	317.4	4	59	176	640.2	460.1	41.14	105.5	120.8
Run 33	0.5	0.5	317.4	4	59	194	811.3	145	69.42	216.4	138
Run 34	0.5	0.5	259.9	4	41	140	476.3	142	62.26	51.92	92.89
Run 35	0.5	0.5	313.9	4	41	158	661.4	168.8	64.78	54.12	100.8

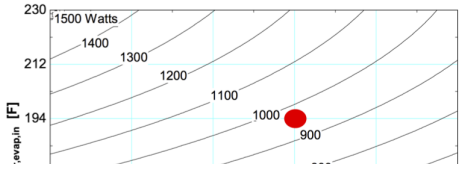
R134a Performance Chart

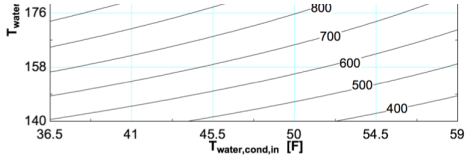




CO2 Performance Chart

4 GPM Condenser Water
0.5ft Condenser Width
0.5ft Evaporator Width

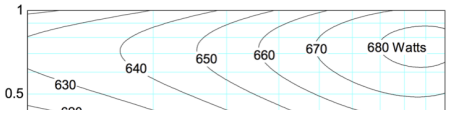


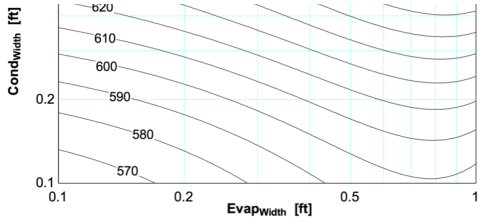


CO2 Performance Chart

File:D:\EES32\Co2 rankine cycle_HX2.EES 12/9/2012 5:02:33 PM Page 5
EES Ver. 7.898

1 GPM Evaporator Water 194F
2 GPM Condenser Water 50F





Higher Temperature R245fa and CO2 Transcritical

Review

The next charts are comparing R245fa and CO2 at higher temperatures. R134a was not included since it has a low critical temperature (about 214 F). I also could not go up to 500 C with either of the other refrigerants as I will detail below.

The reports show net work out with evaporator inlet water temperature starting at 100 C and incrementing 10 C (table on 2nd page). All conditions are normalized to 1 gpm of hot water and 4 gpm of cold water at 10 C (50 F).

R245fa - rankine cycle:
100 C = 1206 W net output shaft power
180 C = 3624 W net output shaft power (15 percent efficiency at this point)
210 C = 4816 W net output shaft power (15 perdent efficiency at this point)
210 C is the max temperature I could run at before the program had difficulty solving since the boiler conditions were reaching the critical temperature of R245fa (154 C). A good visual is the PH diagram (page 3) I have attached that shows the cycle conditions (for 210 C inlet water condition) overlaid over the physical properties of the refrigerant forming the saturated region of the refrigerant or dome. This shows how the cycle gets distorted as the critical temperature is approached

This shows how the cycle gets distorted as the critical temperature is approached.

CO2 transcritical rankine cycle:
100 C = 1152 W net output shaft power
180 C = 1593 W net output shaft power (8.3 percent efficiency)
180 C is the max temperature I could run at before the program had difficulty solving since the condenser was reaching the critical temperature of CO2 (31 C). A good visual is the PH diagram I have attached (page 3) that shows the cycle conditions (for 180 C inlet condition) overlaid over the physical properties of the refrigerant forming the saturated region of the refrigerant or dome. This shows how the condenser is barely living inside the dome of CO2.

This shows the R245fa cycle outperforming CO2 at these conditions by quite a bit. I believe this is because R245fa is a more efficient refrigerant at these conditions.

I would also suggest running the CO2 at fully supercritical conditions (lifting the condenser out of the dome) and making it a Brayton cycle at that point (compressing gas out of condenser instead of pumping liquid). This would be done by elevating the condenser inlet water from 10 C to 35 C (which may be a more practical analysis at these conditions since the condenser heat could then be rejected using a cooling tower instead of relying on a cold water supply). Of course if you wanted 500 C inlet water temperature then only CO2 will work unless, at that condition, you have another refrigerant to compare to.