Hybrid Geothermal-Solar Power Plant

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Background & Description:

Renewable energy sources (such as solar, geothermal, wind, hydro, and biomass) are limitless and environmentally benign. In this simulation, a hybrid cycle of solar-geothermal power production is simulated. The geothermal fluid source (pure water) is assumed to be 150 °C water with 10 bar pressure (Figure 1). This part is coupled with a Rankin cycle using a heat exchanger, which is working at close to 150 °C with R143a fluid. In the solar cycle (Figure 2), therminol VP1, which is a mixture of 73.5% diphenyl oxide and 26.5% biphenyl, is used as the heat transfer fluid. This cycle is working at 395 °C and is coupled with another Rankine cycle, with a heat exchanger, which uses steam as the operating fluid to produce power. To couple solar and geothermal power production together, the geothermal unit is used as a fluid transfer medium [1].

The following formulas (from Solutia Inc.) are taken into consideration to override the properties of DWSIM for calculating the properties of Therminol VP1. These are the following equations: liquid density and heat capacity, and vapor density and heat capacity, respectively.

$$\rho^L = -0.90797T + 7.8116 \times 10^{-4}T^2 - 2.367 \times 10^{-6}T^3 + 1083.25$$
$$C_p^L = 2.414 \times 10^{-3}T + 5.9591 \times 10^{-6}T^2 - 2.9879 \times 10^{-8}T^3 + 4.4172 \times 10^{-11}t^4 + 1.498$$
$$\rho^V = -0.0303917T + 4.34615 \times 10^{-4}T^2 - 2.41006 \times 10^{-6}T^3 + 5.33458 \times 10^{-9}T^4 + 0.092709$$
$$C_p^V = 3.703 \times 10^{-3}T - 3.0274 \times 10^{-6}T^2 + 2.9324 \times 10^{-9}T^3 + 0.92709$$

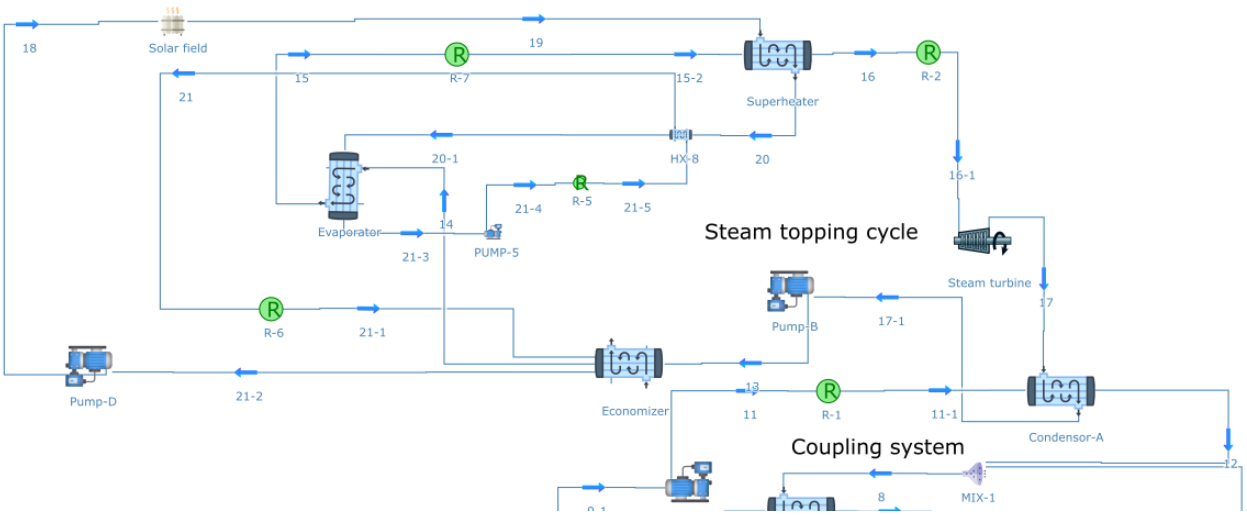

Figure 1: Solar part of the hybrid power plant

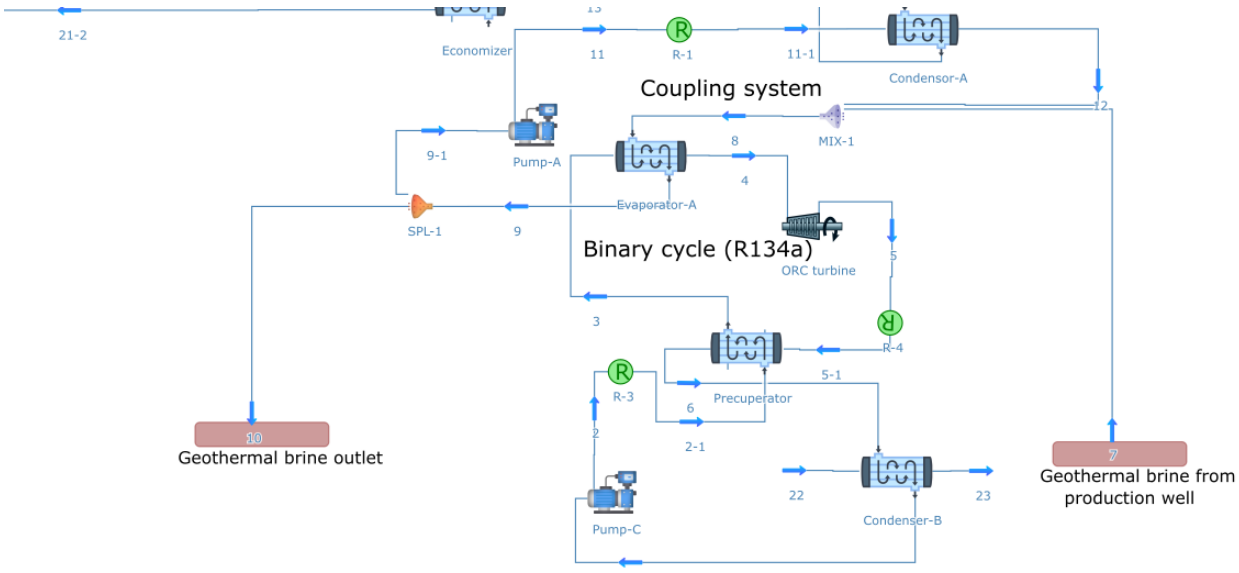

Figure 2: Geothermal part of the hybrid power plant

Results:

Table 1: Results of the simulation

Stream	1	2	3	4	5	6	7	8
Temperature (°C)	27.480	32.441	50.879	147.600	63.980	33.941	150.000	151.487
Pressure (bar)	7.2	56.2	55.7	53.4	7.3	7.2	10.0	10.0
Mass flow (kg/s)	154.50	154.50	154.50	154.50	154.50	154.50	82.50	100.00
Stream	9	10	11	12	13	14	15	16
Temperature (°C)	71.810	71.810	71.813	158.481	170.969	270.900	276.000	390.000
Pressure (bar)	10.0	10.0	10.2	10.0	60.4	60.2	60.2	60.0
Mass flow (kg/s)	100.00	82.50	17.50	17.50	3.15	3.15	3.15	3.15
Stream	17	18	19	20	21	22	23	-
Temperature (°C)	169.997	251.106	395.000	370.895	285.800	15.000	33.941	-
Pressure (bar)	7.9	1.5	1.4	1.3	1.2	1.0	1.0	-
Mass flow (kg/s)	3.15	23.50	23.50	23.50	23.50	676.20	676.20	-

References

[1] Massomeh Alibaba, Razieh Pourdarbani, Mohammad Hasan Khoshgoftar Manesh, Guillermo Valencia Ochoa, and Jorge Duarte Forero. Thermodynamic, exergo-economic and exergo-environmental analysis of hybrid geothermal-solar power plant based on orc cycle using emergy concept. *Heliyon*, 6(4):e03758, 2020.