Kalina cycle with double turbine and reheating

Francis Parra

Escuela Superior Politécnica de Chimborazo

Escuela de Ingeniería Química

Background

The kalina cycle is a thermodynamic power cycle with great potential to generate energy from low-temperature sources. This cycle and the organic Rankine cycle, are a promising alternative to put aside the production of energy based on fossil fuels and take advantage of renewable heat sources such as geothermal or solar.

The kalina cycle is a power cycle that operates with low heat sources and uses a binary mixture that is generally ammonia-water as the working fluid. Due to the temperature variation in the cycle, the composition of the working fluid changes throughout the cycle. Several studies have been carried out to improve it, such as: variation in the composition of the working fluid, variation in the composition of the current entering the turbine, increase in turbine inlet pressure, variation in temperature of warming, combined use with other power cycles and the use of a second turbine in order to increase the efficiency of the cycle.

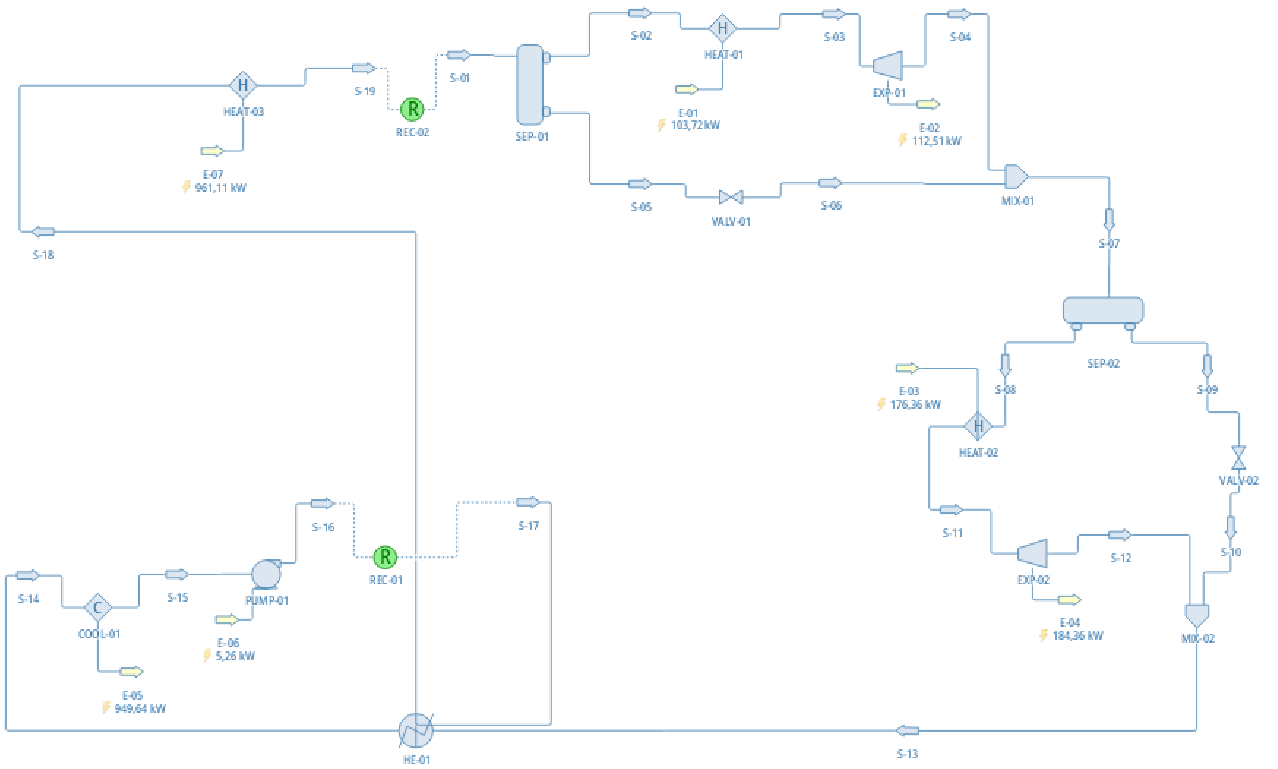
Flowsheet Description

Stream S-01 is an ammonia-water mixture at 40 bar and 0.64 mole fraction. It enters in to Sep-01 where vapor phase rich in ammonia is separated from the liquid phase. The vapor phase then is heated to 468.6 k and it is expanded in a turbine to an intermediate pressure, at the beginning it was 30 bar. S-05 that was the liquid phase is expanded in valve to the intermediate pressure and then is mixing with the stream that leaves the turbine. Then the mixture is sent to Sep-02 in order to produce more vapor rich in ammonia (S-08) that is heated to 481.5 k and expanded in the second turbine to 4 bar. S-09, liquid from Sep-02, is expanded in a valve to 4 bar and then mixed with the outlet stream of the second turbine. The mixture is used to preheat the stream S-16 before enters in to the heater.

Cooled mixture S-14 is cooled in Cool-01 to 279.4 k and it is compressed in a pump to 40 bar. Then it is preheating in HE-01 and enters in HEAT-03 where is heated to the conditions of the stream S-01.

Finally, a sensitivity analysis was carried out in order to find the intermediate pressure that produce the best efficiency of the cycle.

Flowsheet



Results

Object	S-10	S-09	S-08	S-07	S-06	S-05	S-04	S-03	S-02	S-01	
Temperature	338,09	376,36	376,36	376,36	373,81	408,59	378,55	468,60	408,59	408,59	K
Pressure	4,00	15,55	15,55	15,55	15,55	40,00	15,55	40,00	40,00	40,00	bar
Mass Flow	0,31	0,31	0,69	1,00	0,37	0,37	0,63	0,63	0,63	1,00	kg/s
Specific Enthalpy (Mixture)	-1856,24	-1856,24	127,53	-494,36	-1571,34	-1571,34	128,21	305,73	142,17	-485,55	kJ/kg
Molar Fraction (Mixture) / Ammonia	0,37	0,37	0,96	0,78	0,47	0,47	0,95	0,95	0,95	0,78	

Object	S-19	S-18	S-17	S-16	S-15	S-14	S-13	S-12	S-11	
Temperature	408,59	341,74	279,77	279,77	279,40	313,15	341,98	357,56	481,50	K
Pressure	40,00	40,00	40,00	40,00	4,00	4,00	4,00	4,00	15,55	bar
Mass Flow	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,69	0,69	kg/s
Specific Enthalpy (Mixture)	-485,55	-1446,55	-1743,26	-1743,26	-1748,52	-799,14	-502,42	115,78	384,31	kJ/kg
Molar Fraction (Mixture) / Ammonia	0,78	0,78	0,78	0,78	0,78	0,78	0,78	0,96	0,96	

Reference

S. DEVI PARVATHY, JAMES VARGHESE. Energy analysis of a Kalina cycle with double turbine and reheating. *Materials Today: Proceedings*, Volume 47, Part 15, 2021, Pages 5045-5051, ISSN 2214-7853, DOI 10.1016/j.matpr.2021.04.636.