Combined Rankine and Brayton Cycle

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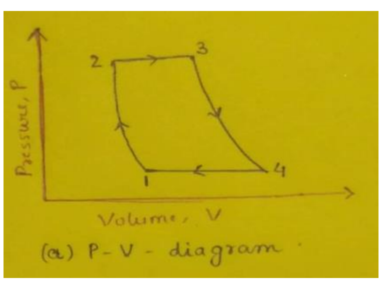
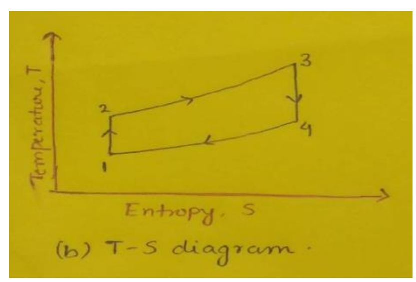
Process Description:

Rankine cycle is also known as the standard vapour-power cycle. Water at low temperature and pressure is compressed isentropically to the boiler pressure by the feed pump. In the boiler, heat is supplied to the water at constant pressure, where its temperature rises to the saturation temperature corresponding to the pressure in the boiler. Further supply of heat results in the evaporation of water and in superheating the vapour produced. The superheated vapour at the elevated pressure in then allowed to expand isentropically in a turbine to the condenser pressure. In the condenser, the low-pressure exhaust steam from the turbine gives out its heat to the cooling water at constant pressure.

The ideal air-standard gas-turbine cycle is known as the Brayton Cycle. The ideal cycle includes an isentropic compression, a constant-pressure heating, an isentropic expansion, and a constant-pressure cooling.





The heat supplied is

$$Q_1 = mC_p\,(T_3 - T_2)$$

The heat rejected is

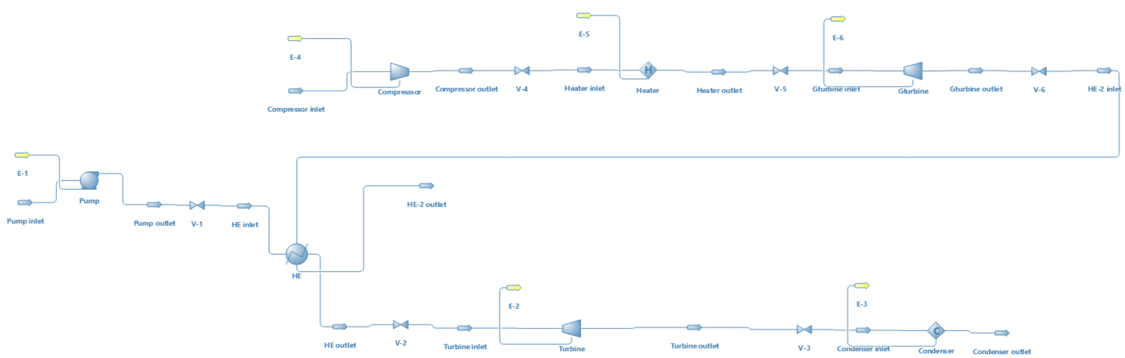
$$Q_2 = mC_p\,(T_4 - T_1)$$

The thermal efficiency is evaluated as

$$n = 1-(Q_2/Q_1)$$

The Flowsheet shows the combined Rankine and Brayton cycle. A Brayton cycle begins by drawing in air from the surroundings through a compressor. The air is then put through a combustor to heat it up, and the heated air is used to rotate a turbine, and some of that work from the turbine goes back to power the compressor. If there's a heat exchanger connecting the two, then the heat generated as waste by a Rankine Cycle can instead be used to power a Brayton cycle. In this way, efficiency increases with less power consumption.

Flowsheet:



Flowsheet 1- Combined Rankine and Brayton Cycle

Results:

Master Property Table								
Object	Turbine outlet	Turbine inlet	Pump outlet	Pump inlet	Heater outlet	Heater inlet	HE-2 outlet	HE-2 inlet
Temperature	347.599	320.001	352.756	236.028	278.684	78.5789	320.164	278.714
Pressure	35	25	75	25	101275	101275	101275	101325
Mass Flow	1	1	1	1	1	1	1	1
Molar Flow	55.5084	55.5084	55.5084	55.5084	34.5304	34.5304	34.5304	34.5304
Volumetric Flow	4583.31	5907.18	2170.61	4357.04	0.789989	0.222749	0.907574	0.789684
Mixture Density	0.000218183	0.000169286	0.000460699	0.000229513	1.26584	4.48936	1.10184	1.26633
Mixture Molar Weight	18.0153	18.0153	18.0153	18.0153	28.96	28.96	28.96	28.96
Mixture Specific Enthalpy	92.6569	40.851	102.367	-115.485	-19.4796	-219.48	22.0661	-19.4497
Mixture Specific Entropy	3.96598	3.96598	3.64198	3.39947	-0.067423	-1.33289	0.071546	-0.0674576
Mixture Molar Enthalpy	1669.24	735.942	1844.17	-2080.5	-564.128	-6356.13	639.033	-563.264
Mixture Molar Entropy	71.4483	71.4482	65.6114	61.2424	-1.95257	-38.6006	2.07197	-1.95357
Vapor Phase Density	0.000218183	0.000169286	0.000460699	0.000229513	1.26584	4.48936	1.10184	1.26633
Vapor Phase Specific Enthalpy	92.6569	40.851	102.367	-115.485	-19.4796	-219.48	22.0661	-19.4497
Vapor Phase Specific Entropy	3.96598	3.96598	3.64198	3.39947	-0.067423	-1.33289	0.071546	-0.0674576
Vapor Phase Molar Enthalpy	1669.24	735.942	1844.17	-2080.5	-564.128	-6356.13	639.033	-563.264

Master Property Table									
Object	HE outlet	HE inlet	Gturbine outlet	Gturbine inlet	Condenser outlet	Condenser inlet	Compressor outlet	Compressor inlet	
Temperature	320.001	352.756	278.714	278.684	320.965	347.599	78.5789	78.5767	K
Pressure	25	75	101325	101275	25	35	101285	101275	Pa
Mass Flow	1	1	1	1	1	1	1	1	kg/s
Molar Flow	55.5084	55.5084	34.5304	34.5304	55.5084	55.5084	34.5304	34.5304	mol/s
Volumetric Flow	5907.18	2170.61	0.789684	0.789989	5924.98	4583.31	0.222727	0.222742	m3/s
Mixture Density	0.000169286	0.000460699	1.26633	1.26584	0.000168777	0.000218183	4.48981	4.48949	kg/m3
Mixture Molar Weight	18.0153	18.0153	28.96	28.96	18.0153	18.0153	28.96	28.96	kg/kmol
Mixture Specific Enthalpy	40.851	102.367	-19.4497	-19.4796	42.657	92.657	-219.48	-219.482	kJ/kg
Mixture Specific Entropy	3.96598	3.64198	-0.0674576	-0.067423	3.97161	3.96598	-1.33292	-1.33292	kJ/[kg.K]
Mixture Molar Enthalpy	735.942	1844.17	-563.264	-564.129	768.477	1669.24	-6356.13	-6356.19	kJ/kmol
Mixture Molar Entropy	71.4482	65.6114	-1.95357	-1.95257	71.5497	71.4483	-38.6014	-38.6014	kJ/[kmol.K]
Vapor Phase Density	0.000169286	0.000460699	1.26633	1.26584	0.000168777	0.000218183	4.48981	4.48949	kg/m3
Vapor Phase Specific Enthalpy	40.851	102.367	-19.4497	-19.4796	42.657	92.657	-219.48	-219.482	kJ/kg
Vapor Phase Specific Entropy	3.96598	3.64198	-0.0674576	-0.067423	3.97161	3.96598	-1.33292	-1.33292	kJ/[kg.K]
Vapor Phase Molar Enthalpy	735.942	1844.17	-563.264	-564.129	768.477	1669.24	-6356.13	-6356.19	kJ/kmol

Master Property Table							
Object	E-6	E-5	E-4	E-3	E-2	E-1	
Energy Flow	-0.029883	200	0.00224067	50	-51.8059	217.852	kW

Reference:

https://lehighmeche.wordpress.com/2017/04/02/a-combined-rankine-and-brayton-cycle/