ENERGY GENERATION BY COMBUSTION OF METHANE

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Abstract

Simulation of a possible electricity generating plant was done from combustion of methane from a biogas source. The plant uses toluene as a working fluid for an in-situ organic Rankine cycle. The objectives of the simulation were;

Main objective;

- Simulate a net 3MW output thermal power plant.

Specific objectives;

- Determine the mass flow rate of toluene needed for an output of 3MW.
- Determine the mass of methane needed to achieve the power output.

FLOW SHEET DESCRIPTION

An ORC cycle consists of a pump (P-01), heater (HT-01), turbine (T-001) and a cooler (Cl-01). The net power output, (E-04) = (E-01) – (E-03). A controller block (C-1) was used to set the targeted energy flow value from stream (E-04) at 3MW. To achieve the target, the mass flow rate of the working fluid was the manipulated property (S-13). The turbine used was 90% efficient and had an inlet specification of 450K and 6 bars. The outlet pressure was 1 atmosphere. The cooler's Cl-01 mode of calculation was outlet vapor mole fraction set at 0 to ensure complete phase transition to liquid. HT-01 was used to heat toluene to 450K. The amount of heat needed to be supplied to the calculated mass was 44.689MW of energy. The combustion of CH_4 to H_20 and CO_2 was the source of energy. To ensure complete combustion in air, the air to fuel ratio enforced by the use of a specification block, was 1:1.7. The thermodynamic model used was Peng Robinson model and the equation $CH_{4\,(g)} + 2\,O_{2\,(g)} \longrightarrow CO_{2\,(g)} + H_20_{\,(g)}$ occurred in an adiabatic conversion reactor. The flue gas temperature was kept at 400K by using a cooler that drew heat from the flue gas. To incorporate heat losses to the environment, the energy drawn had to be slightly higher than 44.689MW. The needed energy value from the boiler was approximated to be 50MW.Another control block was used to keep the energy flow value from energy stream E-07, fixed as 50MW by varying the mass of the fuel in stream S-07. This Rankine cycle used Peng Robinson thermodynamic model.

RESULTS

Master Property Table

Master Property Table												
Object	S-13	S-12	S-11	S-10	S-09	S-08	S-07	S-06	S-05	S-03	S-01	
Temperature	383.818	3317.11	298.139	400	3317.11	298.15	298.15	383.818	383.541	383.541	450	K
Pressure	600000	101325	101325	101325	101325	101325	101325	600000	101325	101325	600000	Pa
Mass Flow	321.449	0	6.46105	6.46105	6.46105	4.06807	2.39298	321.449	321.449	321.449	321.449	kg/s

PROPERTIES TABLE			
SP-1	Expression	1.7*x	
R-01	Methane: Conversion	42.6144	%
P-01	Outlet Pressure	600000	Pa
P-01	Efficiency	75	
HT-01	Efficiency	100	
HT-01	Heat Added	44689.5	kW
HT-01	Pressure Drop	0	Pa
CL-2	Heat Removed	50000	kW
CL-2	Efficiency	100	
CL-2	Pressure Drop	0	Pa
T-001	Pressure Drop	498675	Pa
T-001	Adiabatic Efficiency	90	%
T-001	Power Generated	3374.04	kW
C-1	Set-Point	3100	
C-2	Set-Point	50000	
E4	Energy Flow	3100	kW

Snip of flow sheet