CARBON DIOXIDE CAPTURE INTEGRATED BIOGAS PLANT WITH METHANOL PRODUCTION

Document 2: Aspen plus report

by Team *"EnergreeN"*

CO2- from waste to value

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Objective: To understand the upscaling of the concept provided in the concept report simulation is performed considering a commercial unit. The approximate biogas plant capacity will be 230 ton per day. The simulation is limited to carbon dioxide absorption and methanol production. Biogas plant, power generation and electrolysis process are not incorporated in the simulation.

Version used: Aspen plus V11

CO_2 absorption unit:

Method used: Electrolyte NRTL model with Redlich-Kwong Soave equations of state

Feed specification: 100 kmol/h of dry flue gas (water knocked out) from oxy-combustion of biogas in a biogas power plant with 80% CO_2 and 20% O_2. Solvent use is 30% (mole basis) aqueous solution of 2-amino-2-methyl-1-propanol for CO_2 absorption with a flow rate of 250 kmol/h.

Process description: Dry flue gas enters the bottom of the absorption column and the solvent enters the top of the column. Vent gas from the column is free of CO_2 and the solvent along with the dissolved CO_2 is sent to a stripper for separating the solvent and CO_2. Top product from the stripper contains O_2 which can be separated by membrane separation before sending pure CO_2 to a buffer storage. As the results of the Aspen simulation file shows, CO_2 is captured at the rate of 74.33 kmol/h for a dry flue gas feed rate of 100 kmol/h. The process flow diagram as well as the results of simulation from Aspen Plus are shown in Fig 1 and Table 1 respectively. The recovered stream has a potential for recirculation into the absorber.

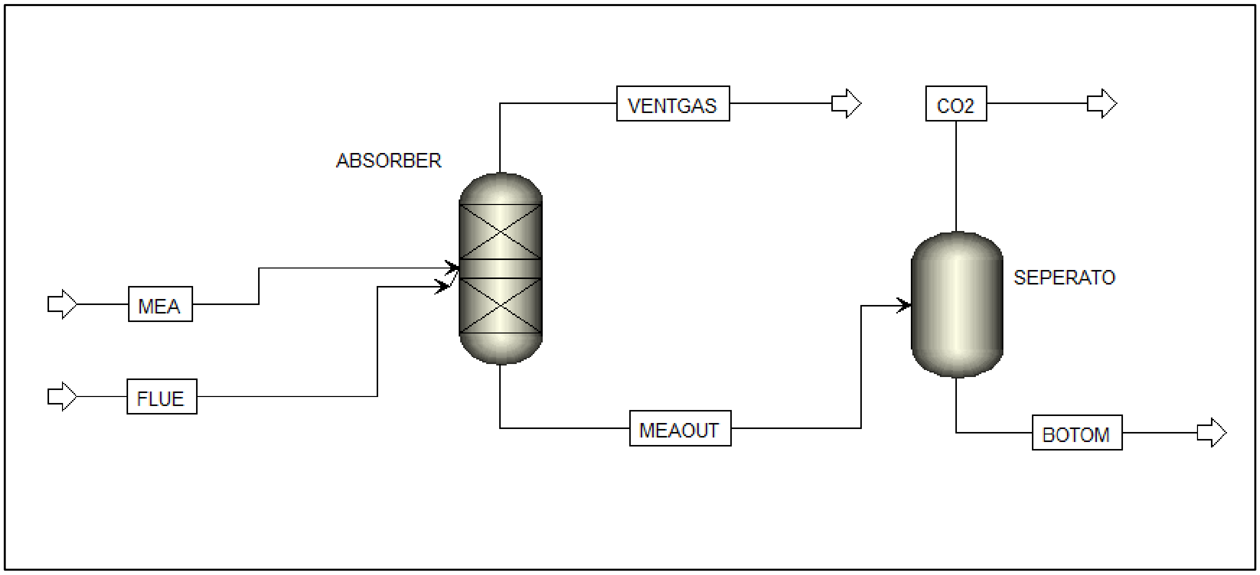

Figure 1: Absorption process flow diagram from Aspen

	Units	BOTOM	CO2	FLUE	MEA	MEAOUT	VENTGAS
Average MW		40.0294	41.1443	41.6076	39.3519	40.3192	32.0972
− Mole Flows	**kmol/hr**	**248.876**	**87.3848**	**100**	**250**	**336.261**	**13.7388**
CARBO-01	kmol/hr	5.53665	74.3329	80	0	79.8695	0.130463
OXYGE-01	kmol/hr	0.0670123	6.34011	20	0	6.40712	13.5929
WATER	kmol/hr	168.276	6.70873	0	175	174.985	0.0154141
MONOE-01	kmol/hr	0	0	0	0	0	0
2-AMI-01	kmol/hr	74.997	0.00304173	0	75	75	3.74343e-06
− Mole Fractions							
CARBO-01		0.0222466	0.850639	0.8	0	0.237522	0.009496
OXYGE-01		0.000269259	0.0725539	0.2	0	0.019054	0.989382
WATER		0.676142	0.0767723	0	0.7	0.520383	0.00112194
MONOE-01		0	0	0	0	0	0
2-AMI-01		0.301342	3.48085e-05	0	0.3	0.223041	2.72472e-07
+ Mass Flows	**kg/hr**	**9962.39**	**3595.38**	**4160.76**	**9837.99**	**13557.8**	**440.976**
+ Mass Fractions							

Table 1: Material balance for absorption of CO_2

Methanol production unit:

Method used: Redlich-Kwong-Soave equation of state with modified Huron-Vidal mixing rules

Feed specification: 74.33 kmol/h CO_2 as obtained from the absorption unit and 222.99 kmol/h H_2 as per stoichiometry of water electrolysis. Isentropic compressors to increase the pressure of the streams to 78 bar and preheater to increase the temperature of the mixed feed stream to 210^o C used.

Reactor Specification: RGibbs reactor at 78 bar pressure and 210^{o}C. The product stream gave a low yield of CH_3OH when simulated in single pass. Hence, flashing combined with recycle of unreacted species was implemented and conversion of CO_2 increased significantly as shown in the results tabulated in Table 2.

Process description: H_2 from water electrolysis and CO_2 from buffer storage are compressed to a pressure of 78 bar for optimum reaction. The feed along with a recycle stream consisting of unreacted species are preheated to a temperature of 210^{o}C. Reaction for production of methanol takes place in a reactor modeled as RGibbs with the operating conditions mentioned above. The product stream from the reactor consists of unreacted gases, CO_2 and H_2 which are flashed and recycled back into the reactor for increasing the overall conversion. The bottom of the flash vessel consisting of methanol and water are sent to a distillation column for purification of methanol. High purity methanol of 96.92% and a molar flow rate of 67.41 kmol/h is obtained at the top of the distillation column. The simulation model is shown in Figure 2.

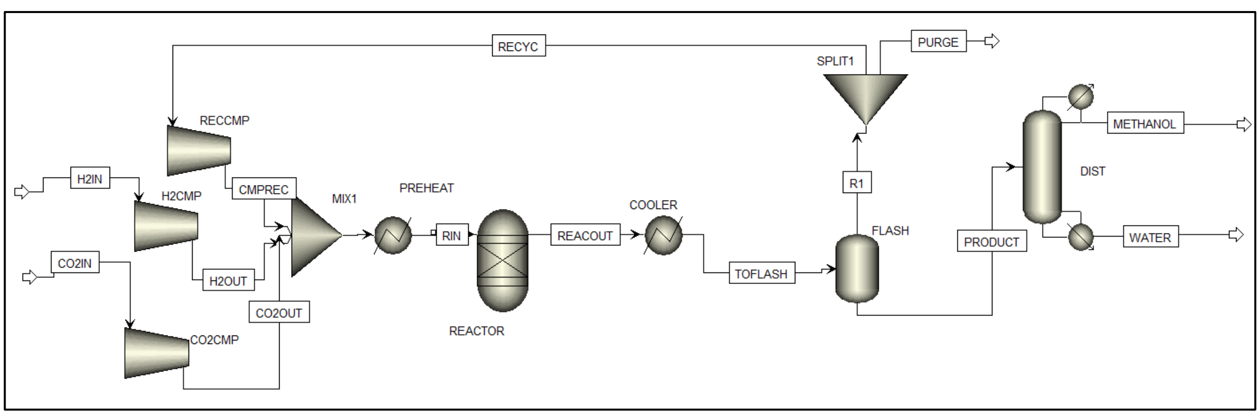

Figure 2: Methanol production flow diagram in Aspen Plus

	Units	H2IN	CO2IN	RECYC	RIN	REACOUT	PURGE	PRODUCT	METHANOL	WATER
Average MW		2.01588	44.0098	15.4915	13.0477	21.4618	15.4915	24.9429	31.6533	18.2325
− Mole Flows	**kmol/hr**	**222.99**	**74.33**	**64.8828**	**362.204**	**220.202**	**16.2207**	**139.098**	**69.5492**	**69.5492**
CO2	kmol/hr	0	74.33	12.7898	87.1209	16.1198	3.19745	0.132575	0.132575	0
H2	kmol/hr	222.99	0	39.8461	262.837	49.8336	9.96152	0.0260003	0.0260003	0
METHA-01	kmol/hr	0	0	10.0735	10.0731	81.0741	2.51837	68.4823	67.405	1.07726
WATER	kmol/hr	0	0	2.17341	2.17325	73.1743	0.543351	70.4575	1.98558	68.472
− Mole Fractions										
CO2		0	1	0.197122	0.24053	0.0732049	0.197122	0.000953104	0.00190621	0
H2		1	0	0.614124	0.725659	0.226309	0.614124	0.00018692	0.000373841	0
METHA-01		0	0	0.155257	0.0278105	0.368181	0.155257	0.49233	0.96917	0.0154891
WATER		0	0	0.0334974	0.00600007	0.332306	0.0334974	0.50653	0.0285493	0.984511
+ Mass Flows	**kg/hr**	**449.521**	**3271.25**	**1005.13**	**4725.94**	**4725.94**	**251.283**	**3469.52**	**2201.46**	**1268.06**
+ Mass Fractions										
Volume Flow	l/min	93731.6	36277.3	27641.6	3165.22	814.779	6910.39	89.8319	59.2424	29.9498

Table 2: Material balance of Methanol production

The power required for the electrolyzer for the production of required quantity of Hydrogen mentioned above is around 14 MW.