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Short Communication

Simulation of DME Production from Carbon dioxide by Indirect Process

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Abstract

Dimethyl ether (DME) is a clean and economical alternative fuel which can be produced from natural gas, synthesis gas and from flue gas. The properties of DME are very similar to those of LPG gas. DME can be used for various fields as a fuel such as power generation, transportation, home heating and cooking, etc. It contains no sulfur or nitrogen. An innovative process of synthesis of DME from flue gas is developed. It is an innovative process since the raw material is one of the greenhouse gases. Carbon dioxide is used for the synthesis. This gas is abundantly available in the environment. The cement industry releases lot of carbon dioxide gas. This gas can be utilized for production of Dimethyl ether. The feasibility of the process is verified using ASPEN simulation.

Keywords: ASPEN plus; Simulation; Dimethyl ether production; Greenhouse gases.

Introduction

There is no universally accepted definition for bulk, fine and specialty chemicals, nor are these classifications based on any intrinsic properties. A working definition of a fine chemical is one with a price of more than 10 USD per kilogram. Future energy demand especially in the pacific and Asian regions is forecasted to be huge. Therefore limited energy supply as well as environmental issue caused by consumption of fuel would be substantial obstacles to realize constant economic growth in these regions. Dimethyl ether (DME), which is recently recognized as a new clean fuel and is synthesized from natural gas, will give a solution of secure energy sup-ply and environmental conservation. Dimethyl ether (DME) is also known as methoxymethane. It is an isomer of ethanol. DME is most commonly used as a replacement for propane in liquid petroleum gas (LPG) and used as a replacement for diesel fuel in transportation. In case of use non-renewable energy causing pollution as well as get exhausted after a period of time. Flue gases contain carbon dioxide gas which is a greenhouse gas and causes air pollution in turn damages the ozone layer. So this gas is used for the production of DME instead. It is as well used as an alternative fuel. It is also used as a refrigerant. Chlorofluorocarbons used as refrigerant can be replaced with DME. There are four different processes used for DME synthesis [1-4].

Carbon dioxide valorization process is selected in the present work for simulation using ASPEN Plus. Carbon dioxide valorization process [4], Instead of the syngas, a CO_2-rich feedstock can be supplied to the DME production process, thus converting the CO_2 in a high added value product. By this process, the CO_2, which is the main greenhouse gas, is not emitted but is converted into a fuel which can be burned releasing again the carbon dioxide [4].

This process is carried out in two steps. The two steps are (i) Production of methanol from carbon dioxide and water [5], and Production of Dimethyl ether by methanol dehydration [6]. Table 1 gives the methanol production process conditions and table 2 gives the methanol to DME process conditions.

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Table 1. Methanol production process conditions

Methanol production	Conditions
Temperature	100- 2400°C
Pressure	75 bar
Catalyst	Copper oxide (CuO)
Reactor type	Fixed bed reactor

Table 2. Methanol to DME process conditions

Methanol - DME	Conditions
Temperature	250-3300°C
Pressure	15 bar
Catalyst	Alumina
Reactor type	Fixed bed reactor

Process Simulation

Flow sheet

The process model flow sheet maps out the entire system. The flow sheet shows one or more inlet streams entering into the system's first unit operation (i.e., heat exchanger, compressor, reactor, distillation column, etc.) and continues through the process, illustrating all intermediate unit operations and the interconnecting streams. The flow sheet also indicates all product streams. Each stream and unit operation is labeled and identified.

Chemical components

The process model specifies all chemical components of the system from the necessary reactants and products, to steam and cooling water.

Operating conditions

All unit operations in the process model are kept under particular operating conditions (i.e., temperature, pressure, size). These are usually at the discretion of the engineer, for it is the operating conditions of the process that affect the outcome of the system. The first step in creating a process model is drawing the flows sheet in ASPEN Plus™. Now, when the process flow sheet is complete, process conditions should be entered. When the simulation is complete the result summary can be printed. Fig. 1 shows the DME production process flow diagram used for simulation [7, 8].

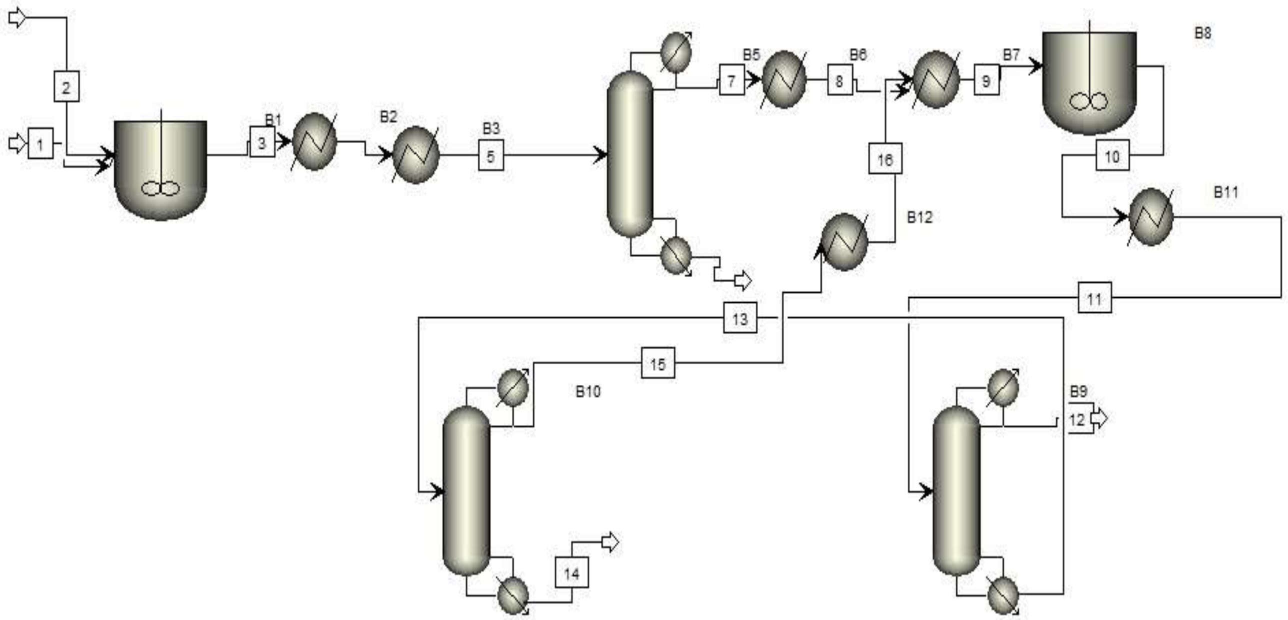
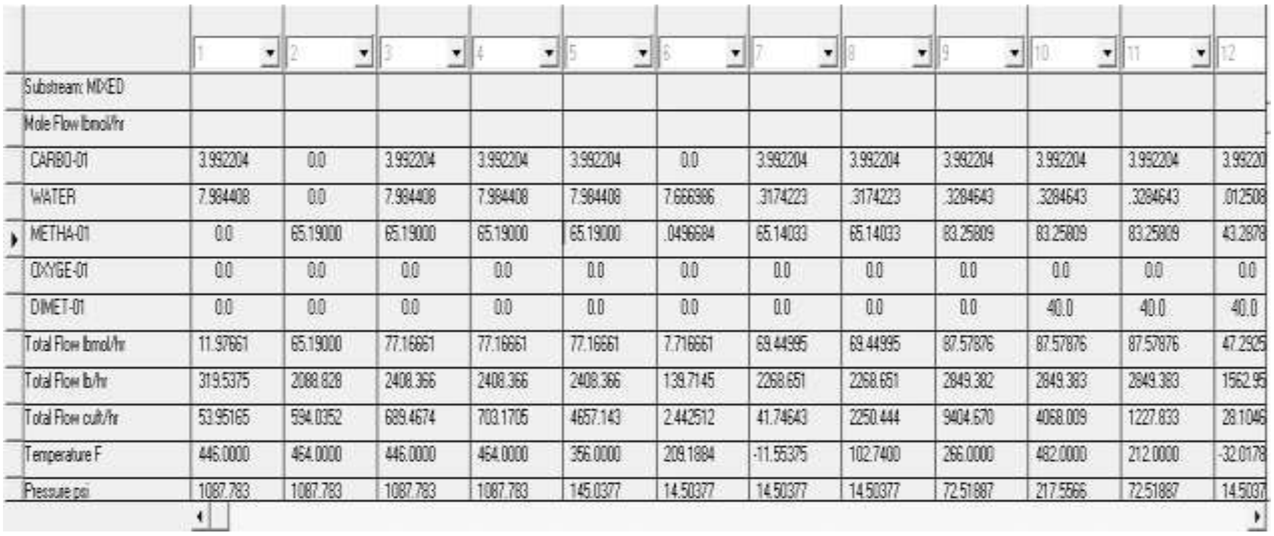


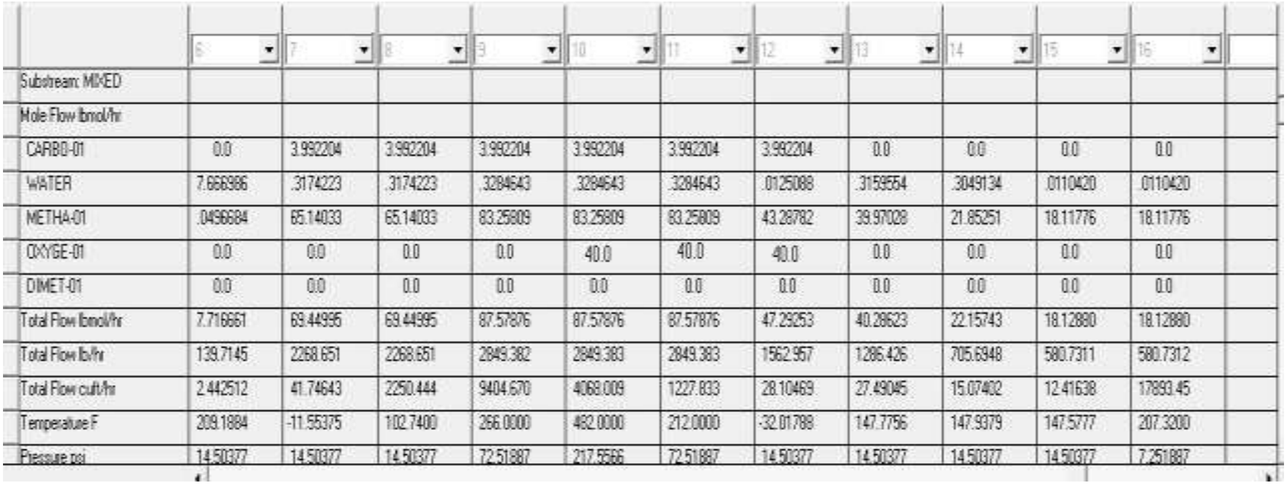
Fig. 1. Simulation of DME Production

Results and discussions

Simulation results of DME Production are shown in Fig. 3. The stream analysis of the DME production was simulated. The process stream results help us to find how effective the process is and the kinetic studies are proved to be correct. The stream data tells the process is feasible to perform in a large scale. The product DME obtained for a small scale is 1000 kg/h. The distillation columns used are effective in the separation process.



	1	2	3	4	5	6	7	8	9	10	11	12
Substream: MIXED												
Mole Flow lbmol/hr												
CARBO-01	3.992204	0.0	3.992204	3.992204	3.992204	0.0	3.992204	3.992204	3.992204	3.992204	3.992204	3.99220
WATER	7.984408	0.0	7.984408	7.984408	7.984408	7.666986	.3174223	.3174223	.3284643	.3284643	.3284643	.012508
METHA-01	0.0	65.19000	65.19000	65.19000	65.19000	.0496684	65.14033	65.14033	83.25809	83.25809	83.25809	43.2878
OXYGE-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIMET-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	40.0	40.0
Total Flow lbmol/hr	11.97661	65.19000	77.16661	77.16661	77.16661	7.716661	69.44995	69.44995	87.57876	87.57876	87.57876	47.2925
Total Flow lb/hr	319.5375	2088.828	2408.366	2408.366	2408.366	139.7145	2268.651	2268.651	2849.382	2849.383	2849.383	1562.95
Total Flow cuft/hr	53.95165	594.0352	689.4674	703.1705	4657.143	2.442512	41.74643	2250.444	9404.670	4068.009	1227.833	28.1046
Temperature F	446.0000	464.0000	446.0000	464.0000	356.0000	209.1884	-11.55375	102.7400	266.0000	482.0000	212.0000	-32.0178
Pressure psi	1087.783	1087.783	1087.783	1087.783	145.0377	14.50377	14.50377	14.50377	72.51887	217.5566	72.51887	14.5037



	6	7	8	9	10	11	12	13	14	15	16	
Substream: MIXED												
Mole Flow lbmol/hr												
CARBO-01	0.0	3.992204	3.992204	3.992204	3.992204	3.992204	3.992204	0.0	0.0	0.0	0.0	
WATER	7.666986	.3174223	.3174223	.3284643	.3284643	.3284643	.0125088	.3159554	.3049134	.0110420	.0110420	
METHA-01	.0496684	65.14033	65.14033	83.25809	83.25809	83.25809	43.28782	39.97028	21.85251	18.11776	18.11776	
OXYGE-01	0.0	0.0	0.0	0.0	40.0	40.0	40.0	0.0	0.0	0.0	0.0	
DIMET-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Flow lbmol/hr	7.716661	69.44995	69.44995	87.57876	87.57876	87.57876	47.29253	40.28623	22.15743	18.12880	18.12880	
Total Flow lb/hr	139.7145	2268.651	2268.651	2849.382	2849.383	2849.383	1562.957	1286.426	705.6948	580.7311	580.7312	
Total Flow cuft/hr	2.442512	41.74643	2250.444	9404.670	4068.009	1227.833	28.10469	27.49045	15.07402	12.41638	17893.45	
Temperature F	209.1884	-11.55375	102.7400	266.0000	482.0000	212.0000	-32.01788	147.7756	147.9379	147.5777	207.3200	
Pressure psi	14.50377	14.50377	14.50377	72.51887	217.5566	72.51887	14.50377	14.50377	14.50377	14.50377	7.251887	

Fig. 2. Simulation Results of DME Production

Conclusions

The discussed process is feasible and friendly to environment. The process reduces the greenhouse gases. The flue gases produced from the cement industry can be utilized for this process. So it is a more economic and convenient process. Since the ASPEN results were obtained, the process can be used on a large scale for DME production.

Conflicts of interest

Authors declare no conflict of interest.

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