Production of DME as an Alternative Fuel Source

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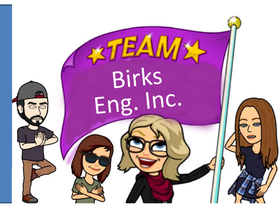


Introduction

- Dimethyl Ether (DME) is a clean and high-performance compression ignition fuel
- Uses include - transportation fuel, aerosol products, and power generation
- Market for DME expected to be worth $9.7 billion[1]

Objectives

- Convert methanol to DME via a gamma alumina catalyst
- Produce 250,000 gal of DME per day

$$2\,CH_3OH \leftrightarrow C_2H_6O + H_2O$$

- Design a safe and profitable process

Critical-to-Quality Variables

- Catalyst Life Time: 12 months[2]
- Composition by mass percent
- Pressure: 75 psi (5.8 atm) to be in liquid form[3]

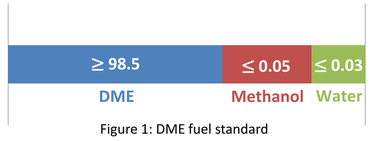


Figure 1: DME fuel standard

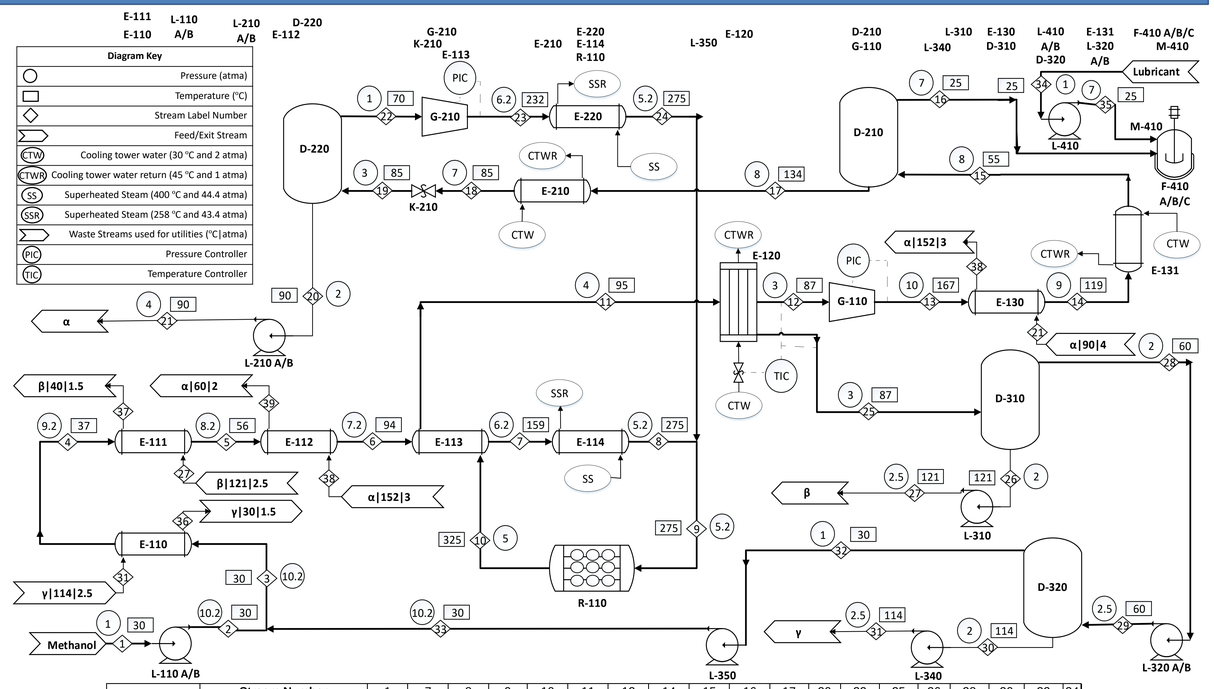
Process Flow Diagram

- Continuous process at 100% and 50% capacity
- Optimized inlet reactor temperature of 275°C
- No methyl formate formation
- Overall 98% conversion of unreacted methanol
- Condenser used to separate water from product
- Innovative energy recovery cycle

Figure 2: Condenser E-120

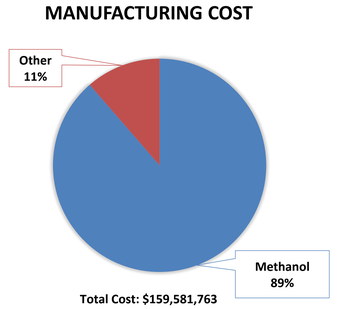
Figure 3: Innovative Energy recovery system

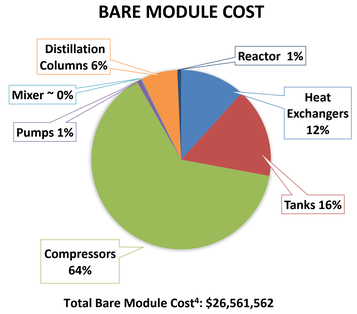
UNIQUAC / UNIFAC thermodynamic model in CHEMCAD accurately describes the dimethyl ether, methanol, and water system throughout the process



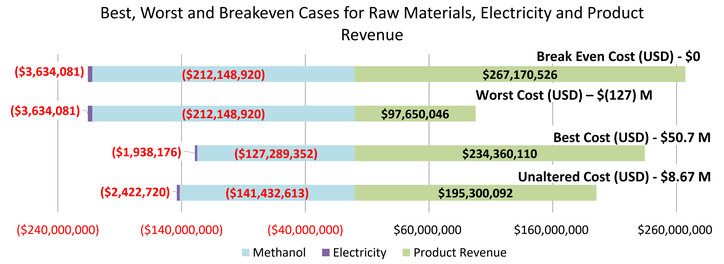
	Stream Number	1	7	8	9	10	11	12	14	15	16	17	20	22	25	26	28	30	32	34
	Total [kg/h]	36871	49179	49179	60576	60576	60576	39446	39446	39446	26147	13299	1902	11397	21130	6480	14650	2342	12308	22
	Pressure [atm]	1	6.2	5.2	5.2	5	4	3	9	8	8	8	2	1	3	2	2	2	1	1
	Temperature [C]	30	159	275	275	325	95	87	119	55	25	134	90	70	87	121	60	114	30	25
	Vapor Fraction	0	0.88	1	1	1	0.54	1	0.97	0	0	0	0	1	0	0	0	0	0	0
	Molecular Weight [kg/kmol]																			
Methanol	32.04	36871	46976	46976	57536	21172	21172	10852	10852	10852	7	10845	285	10560	10320	10	10310	205	10105	0
Water	18.02	0	43	43	852	11077	11077	2427	2427	2427	1	2426	1617	809	8650	6470	2180	2137	43	0
Dimethyl Ether	46.07	0	2160	2160	2188	28327	28327	26167	26167	26167	26139	28	0	28	2160	0	2160	0	2160	0
Lubricant		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22

Economics

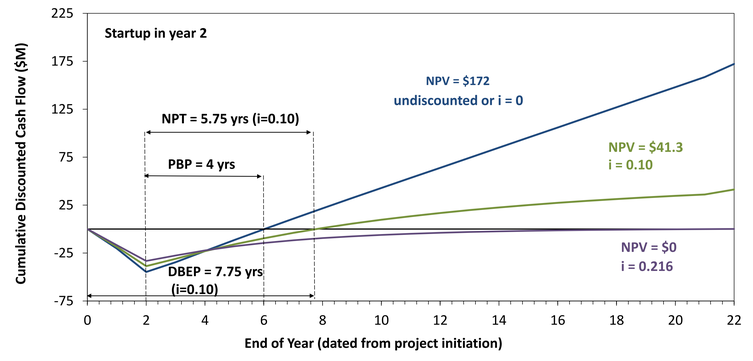




Net Annual Profit After Taxes $8,668,100



- Four operators per shift[5]
- CP Index Value of 575.1[6]
- MACRS 20-year deprecation schedule
- ARR of 29%
- Discounted Rate of 10%
- Discounted NRR 3.4%



Safety, Health, & Environment

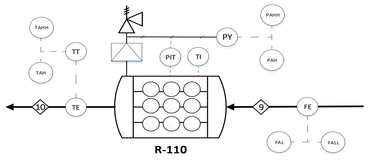


Figure 4: The P&ID for the packed bed catalytic reactor

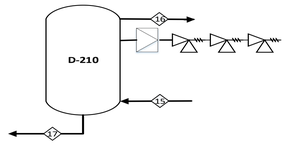


Figure 5: Relief valve selection and placement for distillation columns

Safety

- HAZOP analysis was conducted around reactor (R-110)
- Appropriate controls and relief valves will be implemented
- Inherently safe design

Health

- DME and methanol are highly flammable

Environment

- Waste water will be sent to a water treatment facility

Assumptions & Conclusions

- Plant operates 350 days a year
- 63.2% methanol conversion in a single pass
- Reaction is mildly exothermic, R-110 does not require a cooling jacket[7]
- DME product contains 900 ppm of Lubrizol LZ539N[8]

Further Recommendations

- Investigate increasing single pass conversion
- Analysis to confirm assumption on cooling jacket for R-110

Project should advance to next stage of development

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References

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