The Continuous Process of Dimethyl Ether as a Transportation Fuel

Lindsay Eggleston, Alexander Karam & Thomas Mastorakos
Department of Chemical Engineering, University of New Hampshire

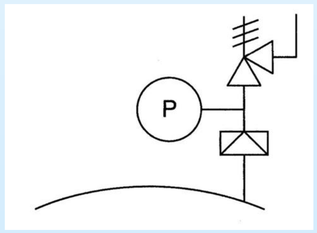
University of New Hampshire

Introduction

- **Objective: Produce 250,000 gal per day of dimethyl ether**
- **Intended to be used as an alternative automotive diesel fuel**
- **DME standard fuel composition requirements:**

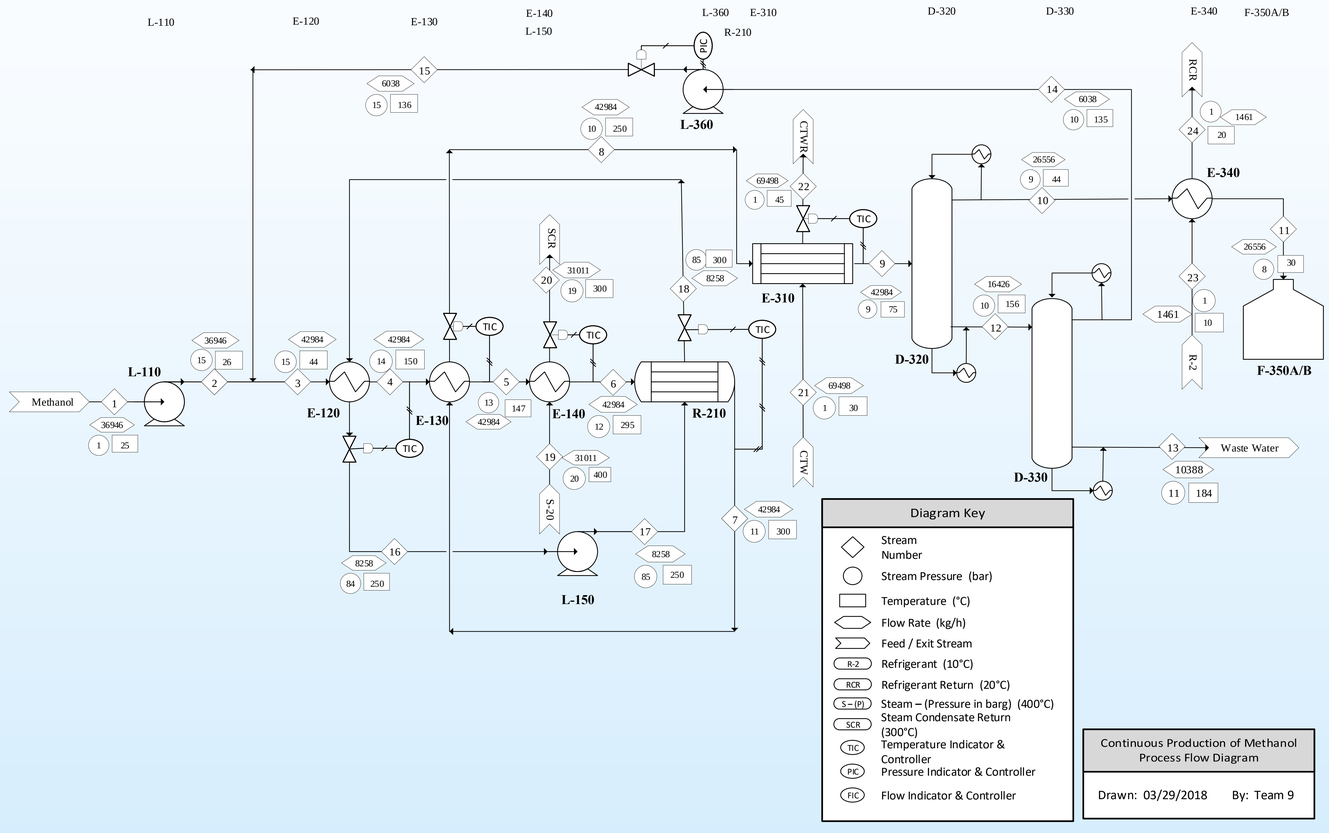
Component	Requirement
Dimethyl Ether (DME)	> 98.5 wt%
Methanol	< 0.05 wt%
Water	< 0.03 wt%

Safety



- **The proposed plant design follows inherent safety design principles**
- **Relief valves were installed on the streams 10, 17, 18 and on F-350 A/B**
- **Rupture disk and downstream spring–loaded relief valve on Streams 2, 6, 7, 14, 15**
- **The most dangerous materials in this process were identified as methanol and dimethyl ether**
- **Waste water (Stream 13) contains <0.1% methanol**

Process Flow Diagram and Material Balance

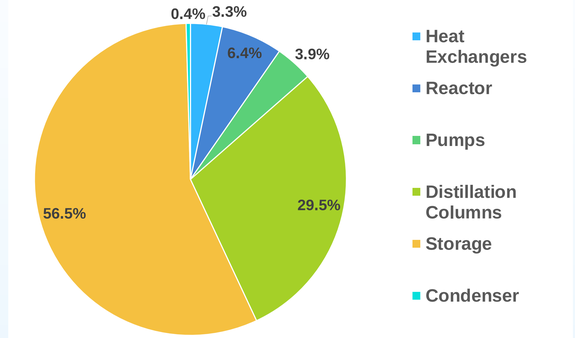


		100% Capacity																						
	Stream	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Flow Rate (kg/h)	36946	36946	43021	43021	43021	43021	42983	42983	42983	26556	26556	16427	10388	6038	6038	29703	29703	29703	31011	31011	69498	69498	1461	1461
	Temperature (°C)	25	26	44	150	147	295	300	250	75	44	25	156	184	135	136	250	250	300	400	300	30	45	10	20
	Pressure (bar)	1	15	15	14	13	12	11	10	9	9	8	10	11	10	15	84	85	85	20	19	1	1	1	1
	Molar Vapor Fraction	0	0	0	0.7	0.83	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Material	MW (kg/kgmol)																								
Methanol	32	36946	36946	42984	42984	42984	42984	6013	6013	6013	6	6	6007	6	6001	6001	0	0	0	0	0	0	0	0	0
Dimethy Ether	46	0	0	27	27	27	27	26577	26577	26577	26550	26550	27	0	27	27	0	0	0	0	0	0	0	0	0
Water	18	0	0	10	10	10	10	10393	10393	10393	0	0	10393	10382	10	10	29703	29703	29703	31011	31011	69498	69498	0	0
Refrigerant	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1461	1461

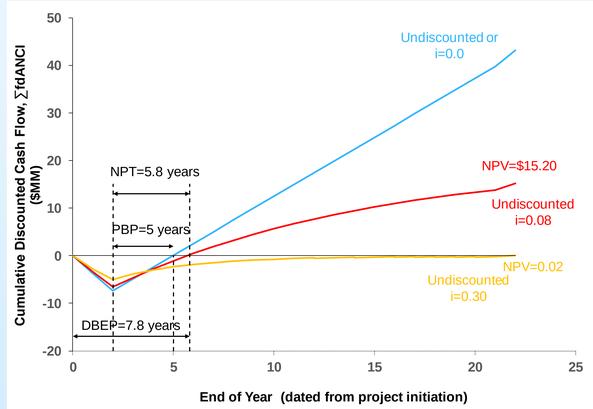
Conclusions & Recommendations

- **It is recommended that the plant design proceeds to the next development step**
- **DME selling price: $2.35 per gallon**
- **Gamma alumina catalyst chosen and favors reaction kinetics**
- **Dimethyl Ether Purity: 99.9% with 0.1% lubricant**
- **Engineered protections in the design to address all safety risks.**

Economic Analysis



- **Total Grassroots Capital Cost: $6.42 million**



- **The NPV of the plant with a discounted annual interest rate of 8% is $15.20 million.**
- **The Discounted Cash Flow Rate of Return (DCFRR) for this process is 30%**
- **The payback period is 5.0 years.**
- **The net payout time is 5.8 years.**
- **The discounted breakeven point is 7.8 years.**

Acknowledgements

We would like to thank the department of chemical engineering at the University of New Hampshire.

References

Ewing, S. (May 2018). *AIChE 2018 Student Design Competition* [Memorandum]. AIChE Student Programs.