Optimizing Absorptive Separation for Intensification of Ammonia Production

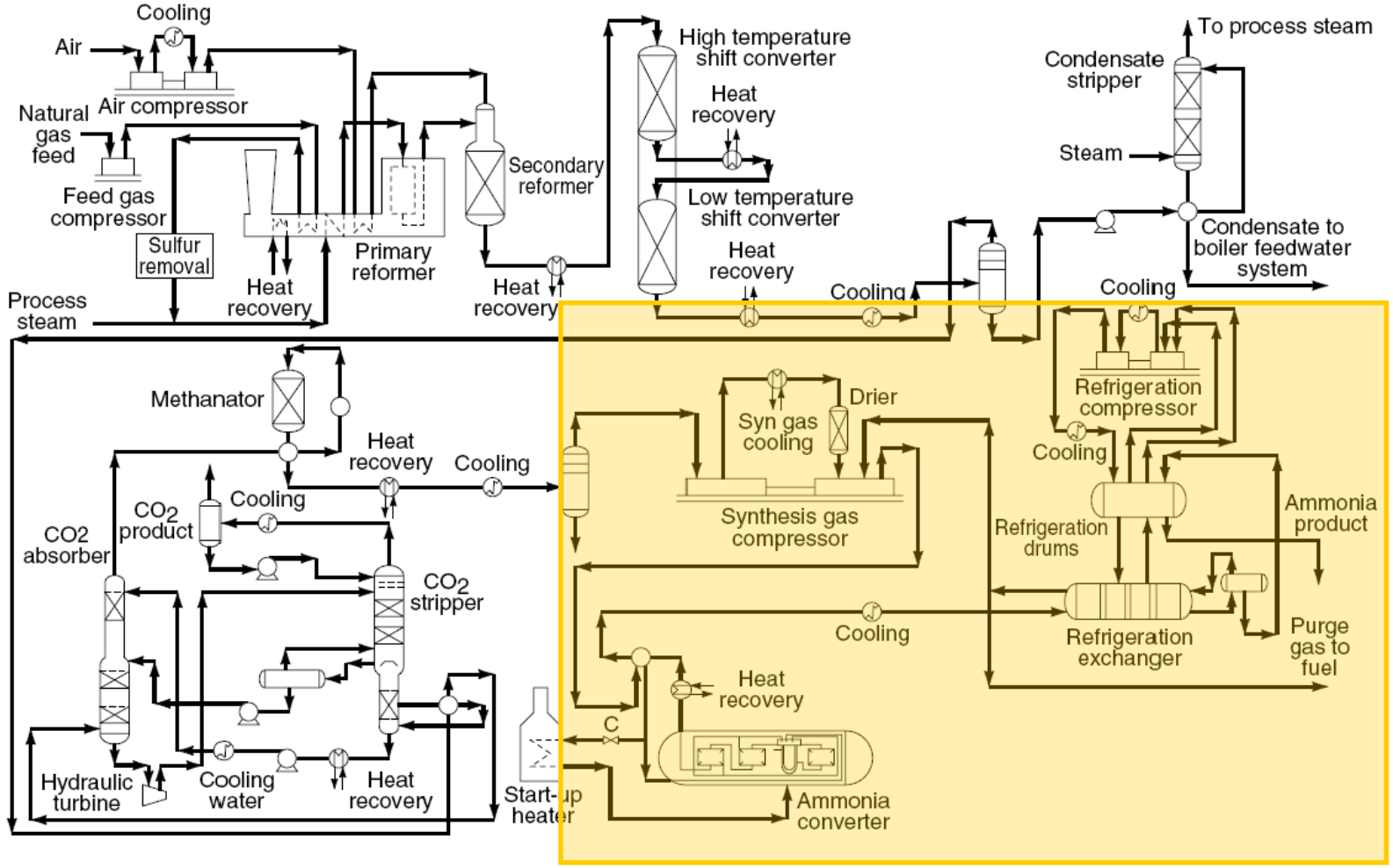
Bosong Lin, Fouzia Nowrin, **Mahdi Malmali**

Chemical Engineering

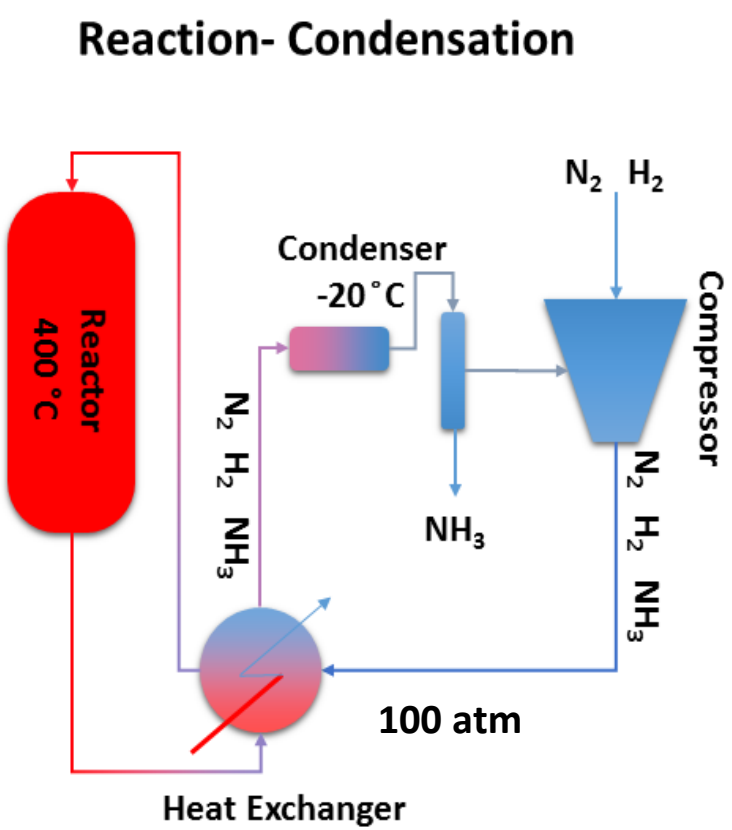
Texas Tech University

Deceptively Simple, yet Complex

Small, Distributed, Modular Processes on Demand

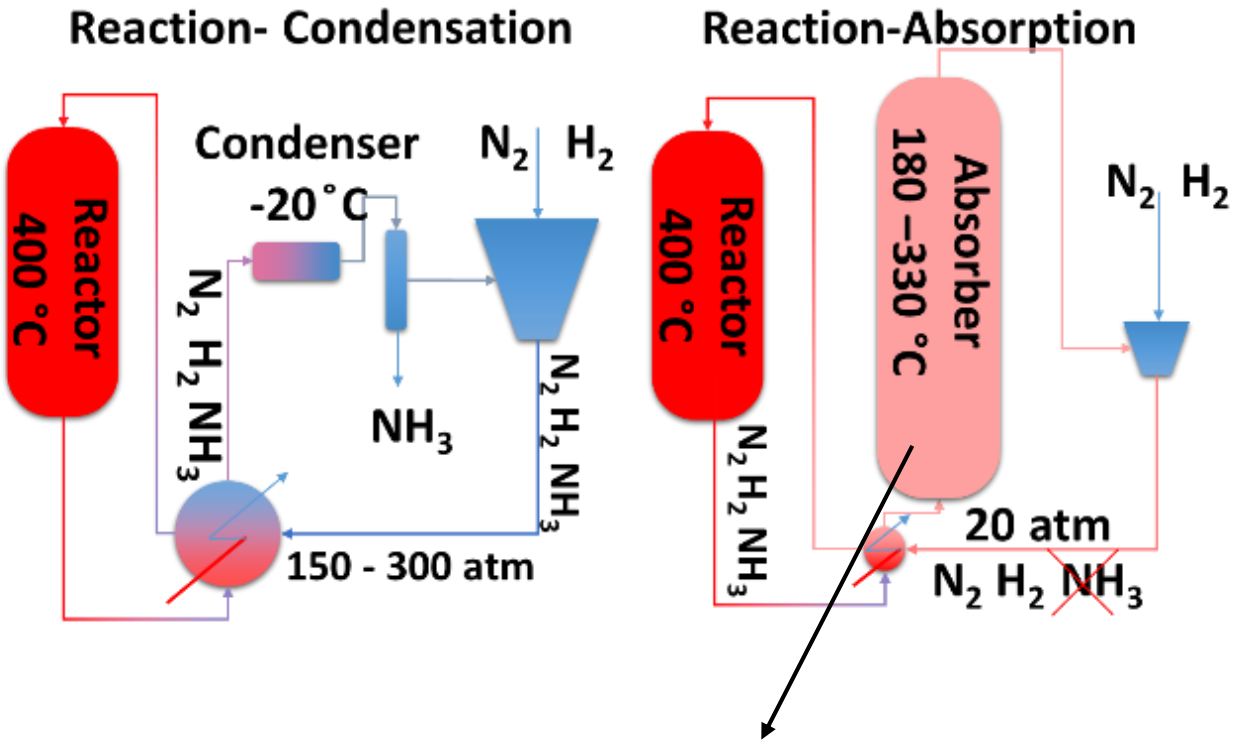


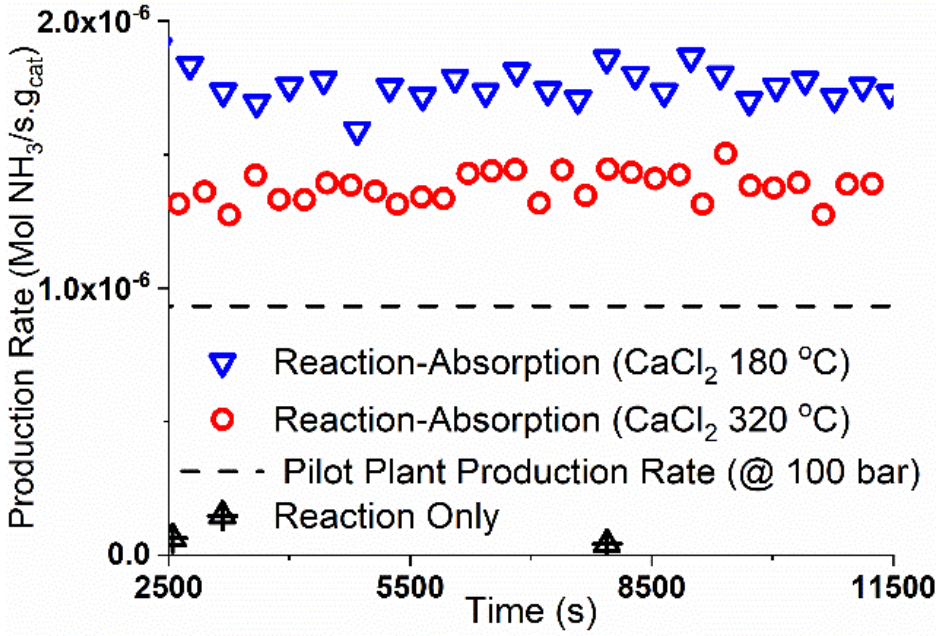
Catalytic ammonia synthesis: fundamentals and practice. Springer Science & Business Media, 2013.



Industrial & Engineering Chemistry Research 55.33 (2016): 8922-8932.
ACS Sustainable Chemistry & Engineering, 6.1 (2018): 827-834.

RXN-CON vs. RXN-ABS





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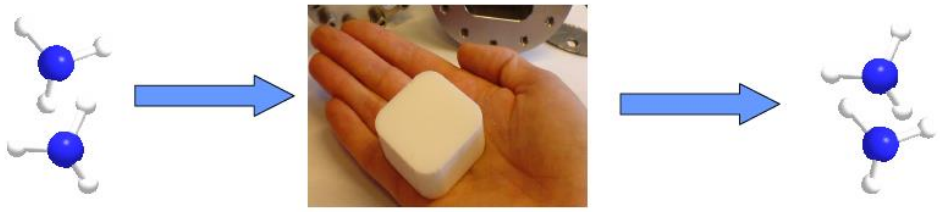


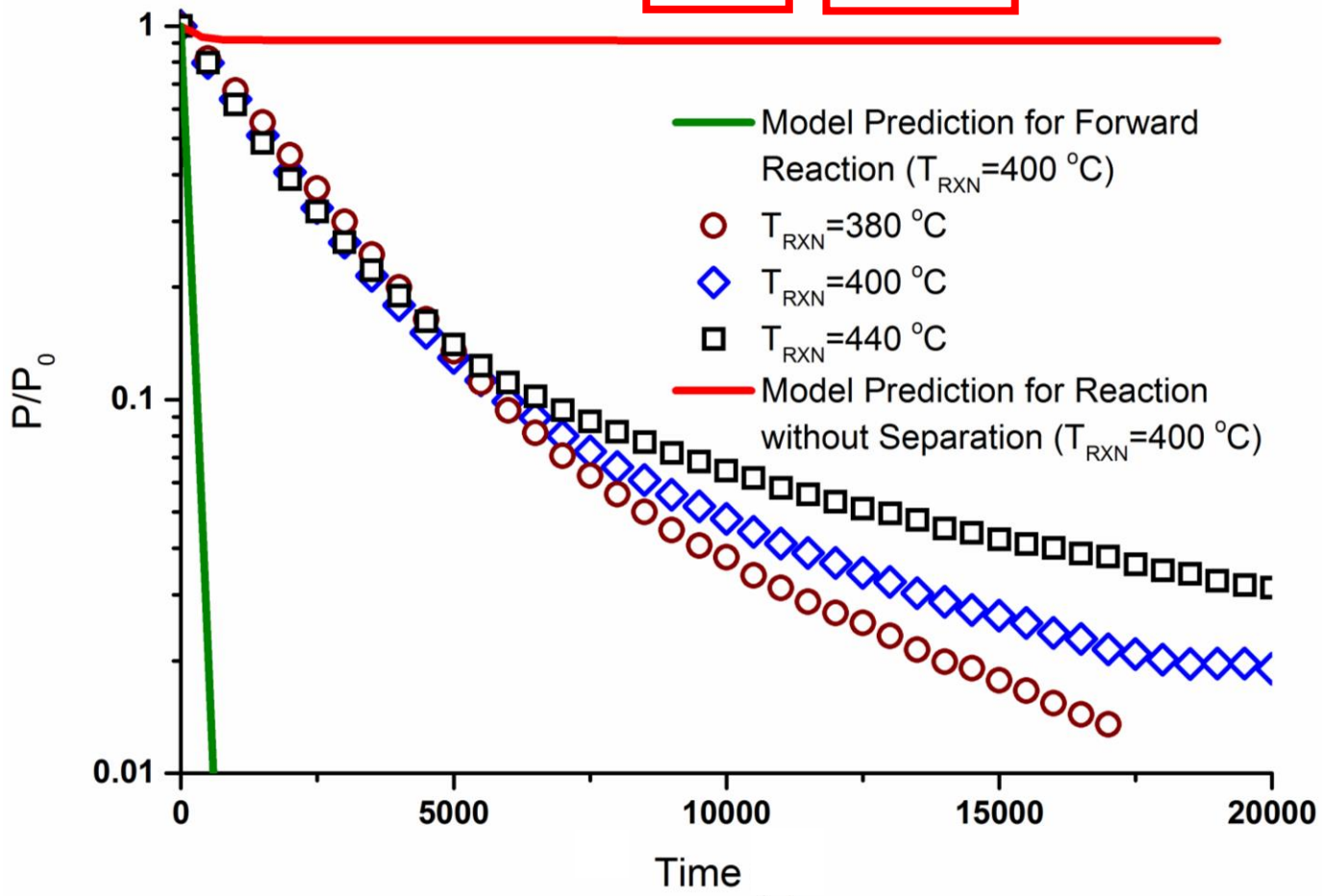
$$MgCl_2 + NH_3 \rightleftharpoons Mg(NH_3)Cl_2$$
$$Mg(NH_3)Cl_2 + NH_3 \rightleftharpoons Mg(NH_3)_2Cl_2$$
$$Mg(NH_3)_2Cl_2 + 4NH_3 \rightleftharpoons Mg(NH_3)_6Cl_2$$

The Journal of Physical Chemistry C, *118*(42), (2014): 24349-24356.

In Reaction-Absorption, Reaction Temperature has ~~Big~~ Little Effect on the Production Rate

$$\textbf{Production Rate} = \frac{C^* - C_0}{\frac{1}{k_R M_R} + \frac{1}{k_{abs} A_{abs}} + \frac{1 - C^*/C}{m}}$$

Batch Process With
P_0= 30 bar
T_{abs}= 200℃



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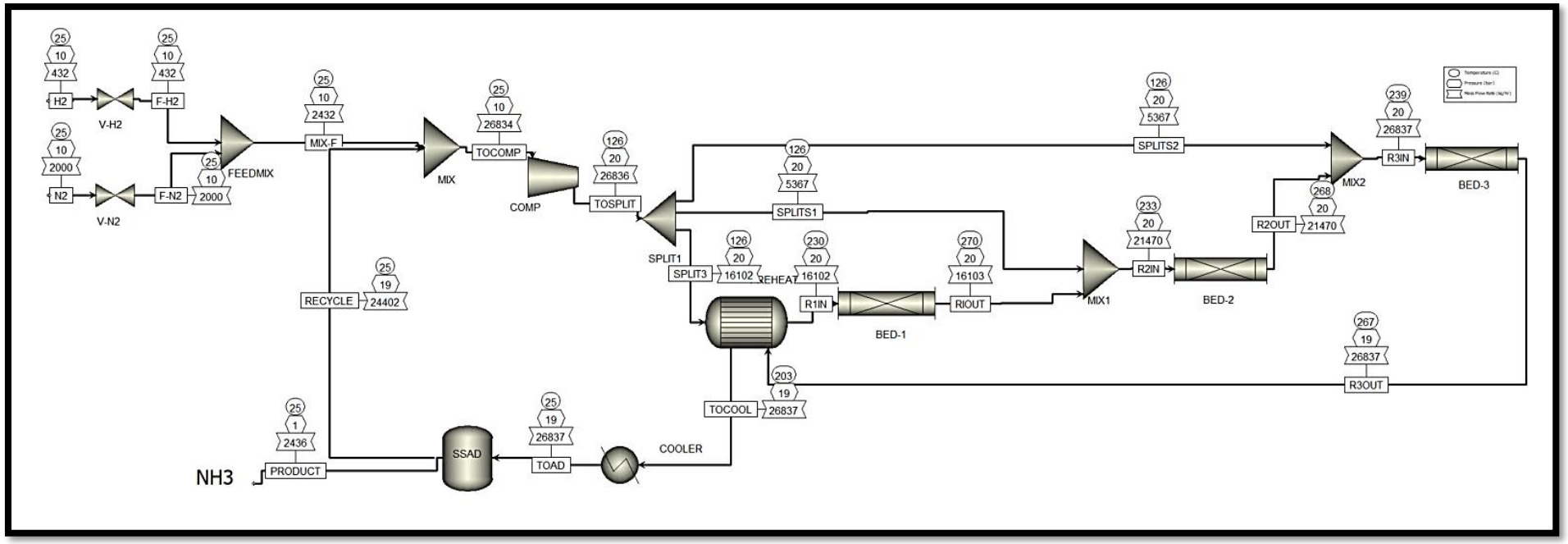
Preliminary thoughts on:

- How to produce 20,000 metric tons of ammonia annually, with reaction-absorption ?
- What is the energy requirement?
- What is the footprint for such facility?
- What is the lowest pressure for a viable process?

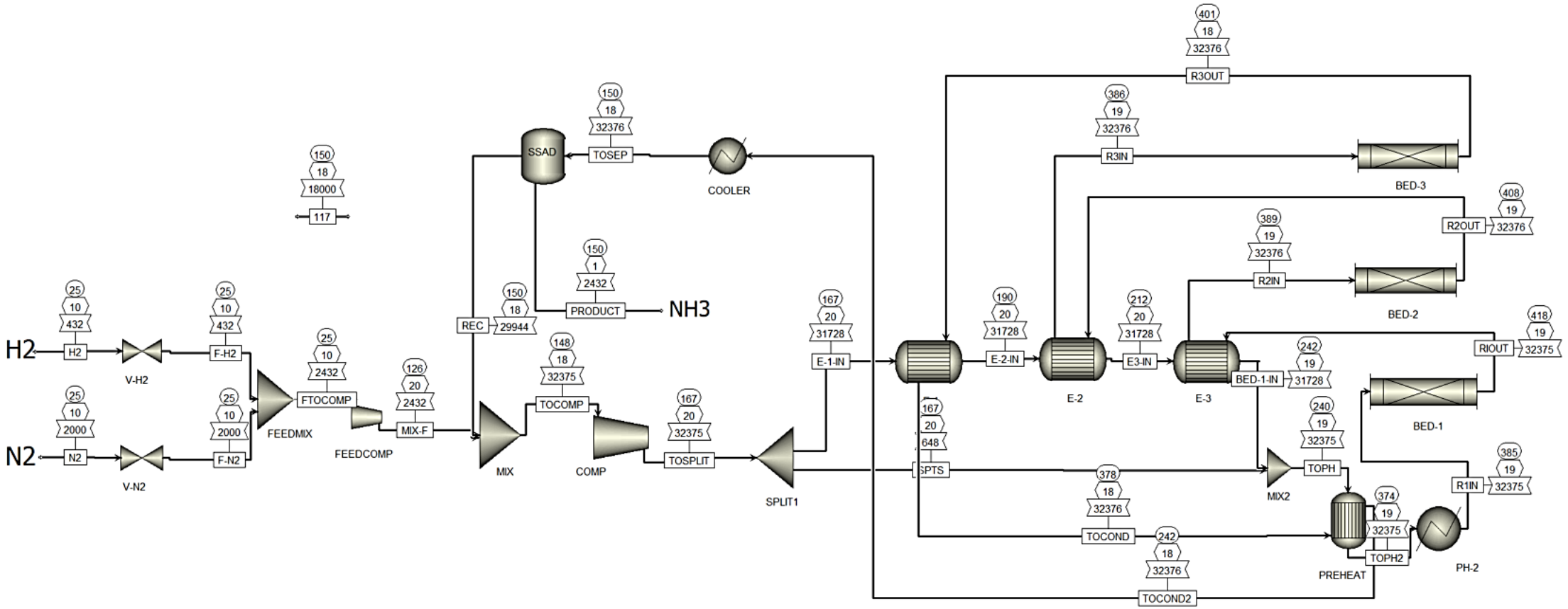
And more …

We should first learn from the conventional RXN-COND process!

RXN-COND as Base Case:



Low Pressure RXN-ABS Process Simulation



Heat Integration is KEY!

Conclusion:

Strategies to Improve Haber-Bosch Process

1- Lower Pressure (depends)

2- Better Separation/Better Sorbents

- Support-free, stable absorbent, and more complete separation

3- Better Catalysis ~~(Not Key Here)~~ should be considered

- More active catalyst at lower temperature benefits low pressure processing

Acknowledgements

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