Synthesis of Ammonia

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INTRODUCTION

Ammonia Synthesis is a common chemical process carried out in plants all around the world. It consists of taking hydrogen (usually from methane or syn gas) and combining it with Nitrogen (generally separated out from the air) to form ammonia ($N_2 + 3H_2 \longrightarrow 2NH_3$). Ammonia is typically used for fertilizers, household cleaning products, and a main ingredient in some explosives.

OBJECTIVES

The purpose of this poster project is to be able to create an ideal theoretical process that converts Nitrogen and Hydrogen into Ammonia and then separate the Ammonia from the residual reactants to achieve a purity of roughly 95% after distillation. Then use a realistic reactor to achieve similar results.

METHODS

- Designed an ideal model of the process using Aspen (Figure 1).
- Tested four different reactors to find the best conversion rate of Nitrogen (Figure 2).
- Used Sensitivity Analysis to determine proper Temperatures and Pressures around a realistic reactor. (Figure 3 & 4).

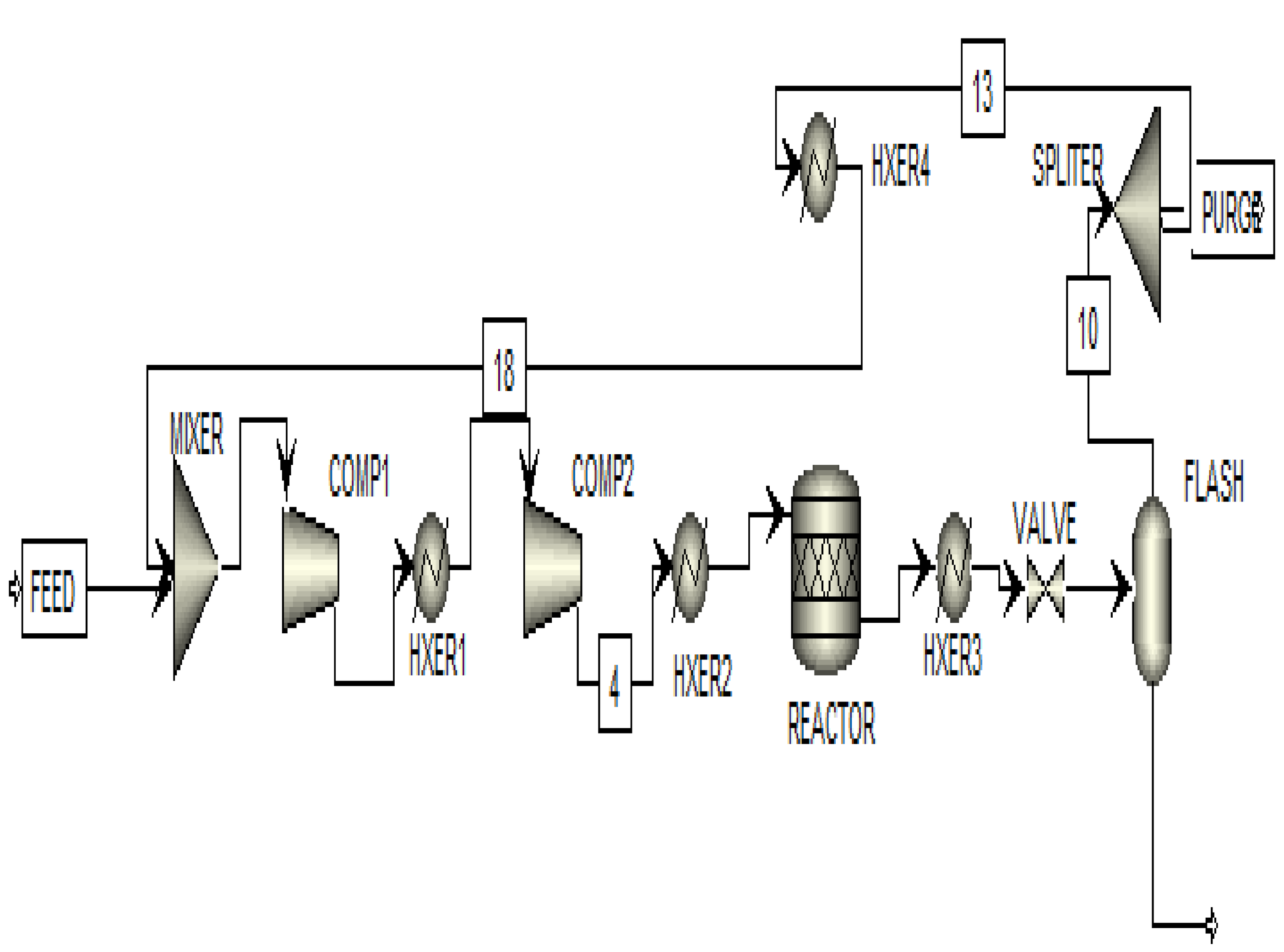

Figure 1. Aspen model of Ammonia Synthesis process.

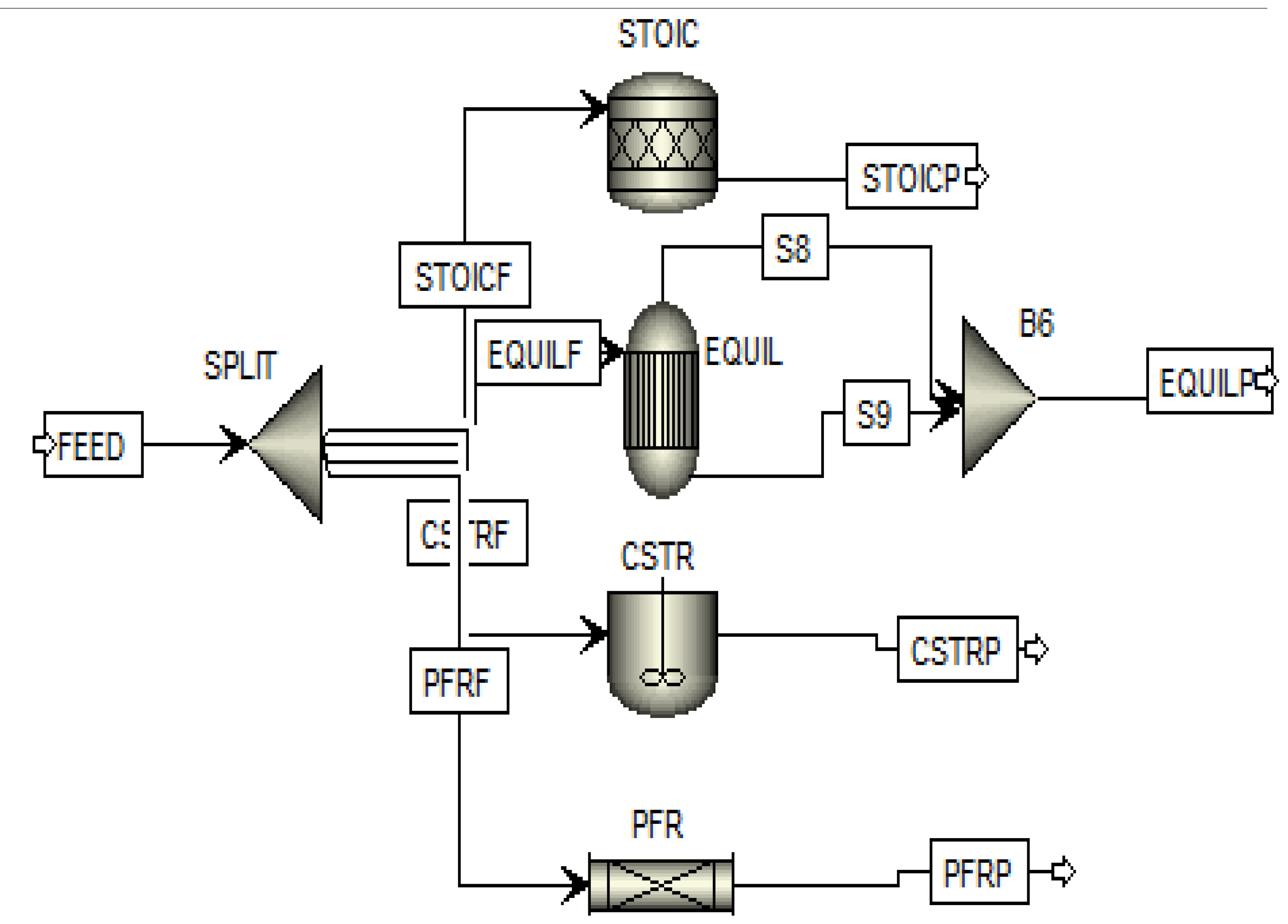

Figure 2. Model used to test Reactor Conversions

RESULTS

- The Stochiometric Reactor is the ideal reactor but is unrealistic, so the CSTR was chosen based on its conversion at a reference temperature of 450°C (83%).
- Optimal Temperature 425-475°C .
- Optimal Pressure 80-90 Atm.
- Leads to a final NH_3 concentration of 90-94% after distillation.

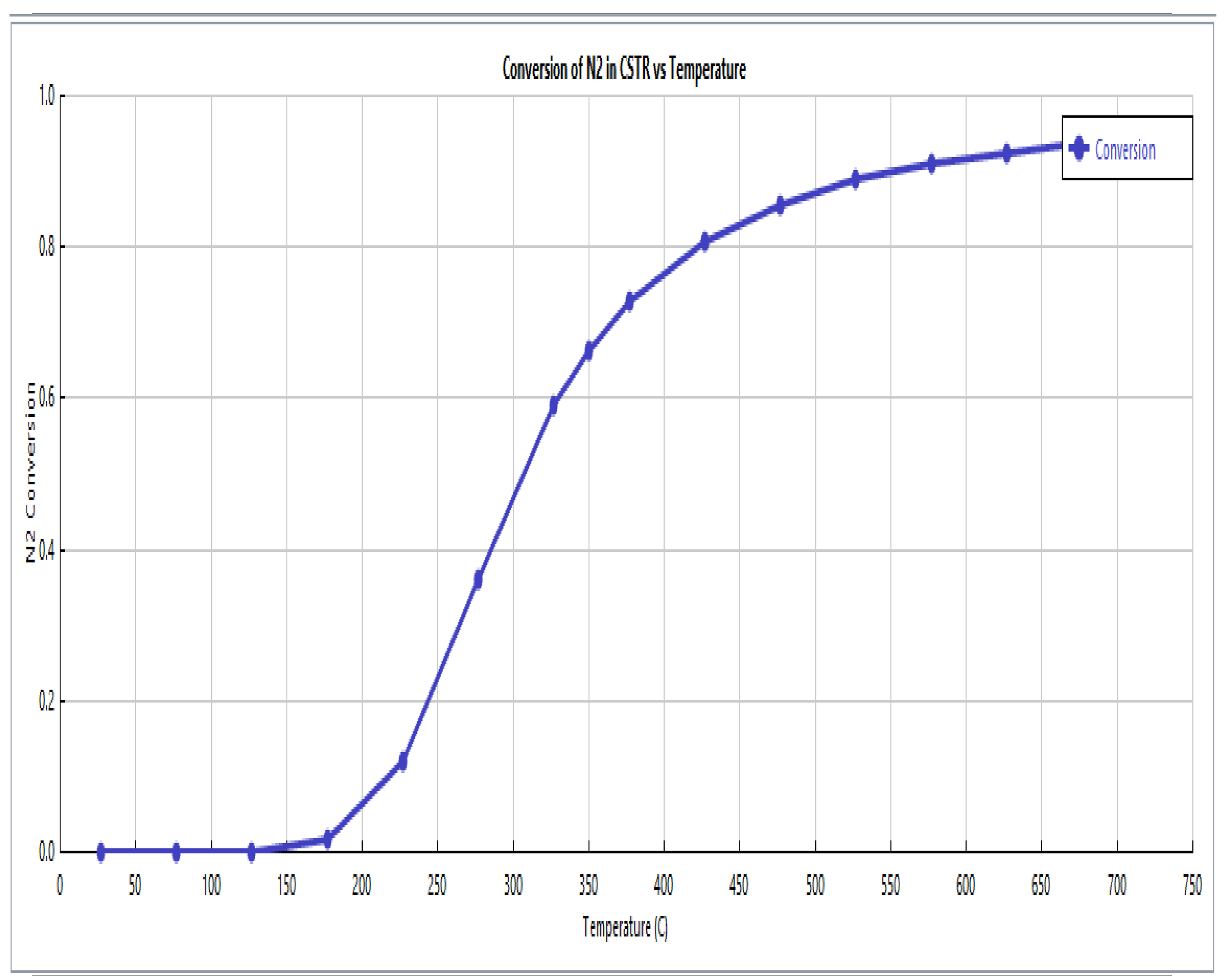

Figure 3. Temperature Sensitivity Around CSTR

CONCLUSIONS

Based on the results from the sensitivity analysis it can be concluded that 83% of your nitrogen can be consumed to form ammonia at a temperature of 450°C and a pressure of 135 atm, the operating conditions of the ideal reactor, using the CSTR. This will produce ammonia with a purity of 97% after distillation.

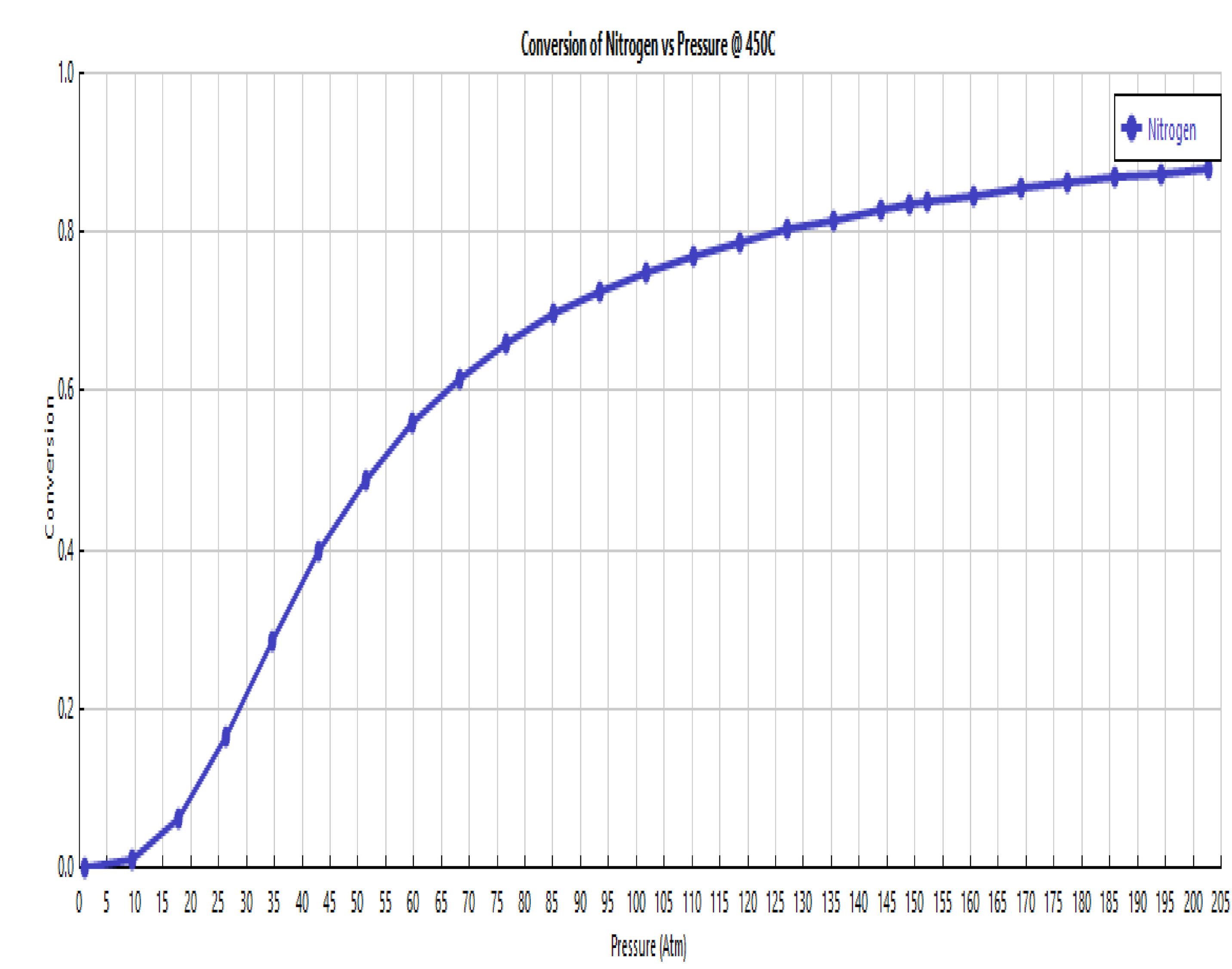

Figure 4. Pressure Sensitivity around CSTR

FUTURE WORK

Further exploratory work can be done to determine the optimal temperatures and pressures for all components of the process such as the heat exchangers and distillation column. Also, an economic analysis to determine the cost of operation for this designed process to determine how economically viable it is.

References

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McCabe, Warren L., et al. *Unit Operations of Chemical Engineering*. 7th ed., McGraw-Hill, 2005.

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