Table 13: Design for Ammonia Reactor

Design parameters	Description
Temperature	250^0C
Pressure	13725.0kpa
Conversion	95%
Feed rate	195500 kg/hr
Configuration	Cylindrical column with hemispherical ends
Orientation	Horizontal
Length	6.2m
Diameter	3.6m
Volume	$21m^3$
Thickness of shell	0.24m
Material of construction	304 stainless steel
Allowable stress	$1.18*10^8 N/m^2$

Urea Synthesis Tower
Equipment type: reactor
Category: fixed bed reactor
Time basis: 1hour
Chemical Reaction: $2NH_3 + CO_2 \Leftrightarrow NH_2COONH_4$
$NH2COONH4 \Leftrightarrow CO\ (NH2)2 + H2O$

Table 14: Design for Urea Reactor

Design parameters	Description
Temperature	30.93^0C
Pressure	12000.00kpa
Conversion	96%
Feed rate	75014.976 kg/hr
Configuration	Cylindrical column with hemispherical ends
Orientation	Vertical
Height	6.1m
Diameter	4.075m
Volume	$79.7m^3$
Thickness of shell	0.24m
Material of construction	304 stainless steel
Allowable stress	$1.18*10^8 N/m^2$

Ammonia Separator
Equipment type: Absorber
Balance: steady state
Time basis: 1hour

Table 15: Design for NH_3 Separator

Design parameters	Description
Temperature	30^0C
Pressure	13675.0kpa
Area	$9.073m^2$
Configuration	Cylindrical column with hemispherical ends

Orientation	Vertical
% loading	60%
Height	8m
Diameter	4m
Volume	$100.5m^3$

Urea Separator
Equipment type: Absorber
Balance: steady state
Time basis: 1hour
Table 16: Design for Urea Separator

Design parameters	**Description**
Temperature	183^0C
Pressure	12000kpa
Area	$9.073m^2$
Configuration	Cylindrical column with hemispherical ends
Orientation	Vertical
% loading	60%
Height	8m
Diameter	4m
Volume	$103.6m^3$

3.3 Discussion of Results

From the feed stock; methane, steam and air with the flow rate of 7678kmol/hr CH_4, 19190kmol/hr steam, and 3584kmol/hr air. The targeted plant production capacity of 4407.94kmol/hr (75063.6kg/hr) of ammonia and 971.49kmol/hr (58334kg/hr) of urea was obtained. In the steam methane reforming, 29581.10kmol/hr of hydrogen was produced which combined with 3347.44kmol/hr Nitrogen in the ammonia synthesis reactor.

Material and energy balance results for each of the equipment as well as equipment design has been provided in chapter 3, the equipment design performed shows that the volume of ammonia reactor is $21m^3$, length 6m, diameter 3m, and shall thickness 0.27m. The volume of urea reactor is $79.7m^3$, height 6.1m, diameter 4.075m, and thickness of shall 0.24. Volume of ammonia separator is $100.5m^3$, that of urea is $103.6m^3$ and Absorber (component splitter) is $196.35m^3$.

The ammonia-stripping urea process involves high ammonia to carbon iv oxide ratio in the reactor ensuring high conversion of carbamate to urea. The technology used in this research work differs from other competitors because of the ease of modification, energy efficient, low operating cost and high conversion of carbamat to urea and the use of excess ammonia to avoid corrosion as well as to promote the decomposition of unconverted carbamate into urea.

Cost estimation carried out show that the total purchased cost of equipment is $9,881,055, fixed capital investment is $64,545,522, gross annual earning is $72,422,247, Net annual income is $54,316,685, Rate of return is 38.85% and payback time is 2.5years. The payback time falls within the range of payback period which is between 2–5 years for a typical chemical Engineering plants [15]. This suggests that at this point in time of the project life, the gross profit generated up to this point would be enough to pay off the initial capital investment.

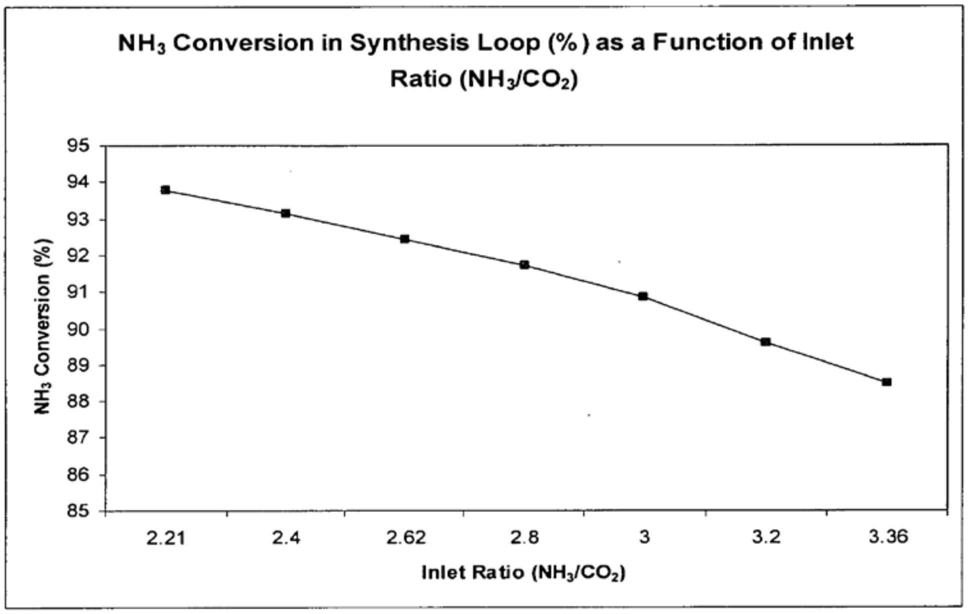

Figure 13: Effect of temperature and pressure on % conversion

From the graph above, a low temperature and higher pressure increases the % conversion of the feed gas to ammonia, but in order to achieve the objective, the temperature have to set to 756^0C and pressure of 13765kpa which are the values obtained from the literature as well as in figure 13

(b) Effect of Catalyst

Catalyst speed up the rate of chemical reaction either by allowing different reaction mechanism or by providing addition mechanism, the overall effect is to lower activation energy (i.e it provide an alternative pathway with lower activation energy), it increases the reaction rate

General Analysis

After building the flow-sheet in the simulation environment, try by error method was used to optimize the plant in order to achieve my targeted plant capacity.

Try by error method was also used in the heat integration network to improve the efficiency of the plant and to save cost and have good economic performance

Figure 14: NH_3 conversion to Urea in synthesis loop as a function of inlet ratio

Figure 14 shows the relationship between conversions of ammonia to urea in the synthesis loop with the inlet ratio NH_3/CO_2. As the inlet ratio is decreased, the overall loop conversion of NH_3 to urea is increasing

CONCLUSION

The simulation of Ammonia-Urea process carried out in this work using Aspen Hysys yield accurate results and the targeted plant capacity was achieved with ease of modification. The Sizing of all the units and results produced throughout the research work has been presented. The process is more environmentally responsible than other ammonia-urea process routes. The product quality depends on the maintenance of appropriate temperature & pressure conditions in the reactors. Moreover, to enhance ammonia-urea production, a recycle stream was installed for more production

Contribution to Knowledge

The Contribution of this research work in line with the objectives is as follows;

Design of an integrated process for the production of ammonia and urea using aspen hysys. A combined ammonia and urea process plant with the giving plant capacity was achieved in this design work, this is the first of its kind

Plant is free from carbon emission. The plant reduces environmental hazards that could result from the effluent by installing a recycle unit, these effluents are treated in the plant and returned in the reactor for further production

Optimization of the developed process in aspen hysys

The hysys model developed can be easily modified

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