Design and simulation of an Ammonium Nitrate Production plant

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Abstract- The design of an ammonium nitrate production plant with a capacity of 310,600 tons per year involves a thorough and systematic approach encompassing various stages. Initially, material and energy balances were meticulously calculated manually to determine the quantities of nitric acid and ammonia required to produce 98% concentrated ammonium nitrate. These calculations were then validated through process simulation using ASPEN HYSYS v11.0, ensuring accuracy and optimizing process conditions.Following successful simulation, equipment design for reactors, heat exchangers, separators, and other units was undertaken, adhering to the specifications derived from the simulation results. Plant layout was carefully planned to maximize operational efficiency, considering factors such as material flow, safety protocols, and accessibility for maintenance.An integral part of the project involved evaluating the profitability of the plant. This included estimating capital costs for construction and installation, as well as operational expenses including raw materials, energy consumption, labor, and maintenance. Financial metrics such as NPV, IRR, and Payback Period were computed to assess the economic feasibility of the venture.Throughout the entire process, environmental and safety considerations were paramount, ensuring compliance with regulations and minimizing risks associated with handling hazardous chemicals. The culmination of this study is a comprehensive design package encompassing detailed documentation of calculations, simulations, equipment specifications, layout plans, and financial analyses, ready to guide the construction and operation of the ammonium nitrate production facility.

1. INTRODUCTION

The ammonium nitrate was first created by German chemist Johann Rudolf Glauber in 1659, but it was not used in explosives until World War I, when weapons manufacturers combined it with Trinitrotoluene (TNT), sometimes known as dynamite, to make less expensive bombs. 58 ammonium nitrate plants in the United States in 1991, spread across 22 states, produced approximately 8.2 million megagrams (Mg) or 9 million tons of ammonium nitrate. Between 15 and 20% of this total was used in the manufacture of explosives, while The remaining part was for fertilizer [1]. Ammonium nitrate is one of the most widely used commercial nitrogen fertilizers, with a mass content of up to 35% nitrogen [2]. It is a white, bead-like crystalline powder. Its melting and boiling points are 169.6 and 210 degrees Celsius, respectively, and its density is 1.72 g/cm3. It dissolves easily in water (H2O) [3]. Ammonium nitrate is often used in fireworks, pesticides, herbicides, and fertilizers. It's additionally used in the nitrous oxide production process. Ammonium nitrate is a food for yeast and antibiotics, an oxidizer in rocket fuel, an absorber of nitrogen oxides, and an ingredient in freezing mixtures. In addition, it is used in mining and explosives (especially as an oil mixture for blasting rocks) [4]. The following equation describes the elementary process by which gaseous ammonia and aqueous nitric acid react to form ammonium nitrate:

$$NH_3 + HNO_3 \rightarrow NH_4OH \qquad \text{, (Equation 1).}$$

The process involves several unit operations including neutralization. Evaporation and solidification (granulation and granulation) [5]. The resulting ammonium nitrate solution can be used in several ways, including storing it as a solution and selling it or using it in downstream processes, and it can also be mixed with a solid filler or converted into solid ammonium nitrate by crushing or granulating it [6].

2.   LITURATURE REVIEW

Many researchers have prepared research on ammonium nitrate production. The focus was on explaining the processes of producing ammonium nitrate, and some additives that can be added to improve their properties or be used in many applications such as fertilizers and explosives.

i.   Ammonium nitrate production process:

The normal Ammonium Nitrate production method has three main unit operations: Neutralization, Evaporation, and solidification(prilling and granulation). A greater temperature and a higher concentration of Ammonium Nitrate (AN) will result after neutralization at a higher pressure. To prevent ammonium nitrate decomposition, nitrogen losses, and local overheating, the components in the reactor must be completely and rapidly combined. The majority of the water in the AN solution must typically be removed using the evaporator. It must generate the necessary concentration of solution at a temperature that prevents crystallization. The appropriate water content is determined by the method employed to create the final product. Prilling is the process by which AN droplets solidify and form granules. Through vacuum evaporation, the AN solution is concentrated from 96% to 99% and forms a "melt."To make sure that the microspheres are distributed uniformly within the prill, surfactants are added before the prilling method. These microspheres, also known as contained gas bubbles, are added to reduce and regulate prill density to desired levels. This enhances the explosive's sensitivity and functionality. while keeping the beneficial characteristics of regular prills. results that come out include Commercial scores for AN solutions with around 83% AN and Solid products. Both grades can be mixed with other materials to produce mixed solid and liquid fertilizers, or they can be applied directly as fertilizer. For direct applications, high-density prilled AN is typically used, whereas other solid AN Is combined with phosphate and potash to create multi-nutrient fertilizers [7].

ii.   Ammonium nitrate fertilizer production based on biomass – environmental effects from a life cycle perspective:

This study aimed to compare the conventional production of nitrogen fertilizers from natural gas with the effects on the environment, fossil energy input, and land use of producing the same product from gasified biomass. The Life Cycle Assessment (LCA) methodology was applied to the evaluation. Since it has been demonstrated that they have a favorable energy balance in terms of input versus output from the field, two types of biomass sources straw from cereal production and short rotation willow (Salix) coppice were investigated [8].

iii.   Mathematical modeling and simulation of an industrial rotary dryer(A case study of an ammonium nitrate plant):

In the fertilizer industry, solids must be dried until the final product meets commercial requirements for quality. The Shiraz Petrochemical Complex (SPC) plant under consideration in this article is built to produce the following as desired 750 metric tons per day of AN pellets, which are used as fertilizer and contain 30% nitrogen by weight; Or 650 metric tons of pure AN. The goal of this project is to create a mathematical model that simulates an industrial rotary dryer for AN particles. It studies the design of the synchronous rotary dryer and investigates the effects of various operational factors on the exit temperature of the solid and the moisture content. Based on industrial experiments, the moisture and temperature of the material are among the most important characteristics that determine the commercial characteristics of the final product when it exits the rotary dryer, as the particle size and agglomeration are affected in a way. Great with these two factors. It was developed to model the AN synchronous rotary dryer mathematically and includes equations for mass and heat transfer between the solid and the air. When the model was compared to industrial data, there was good agreement [9].

iv.   Exergy analysis of ammonium nitrate production plants:

The majority of ammonium nitrate used in fertilizers is created when gaseous ammonia directly neutralizes weak nitric acid, up to 65% of it. Although the neutralization process is exothermic, only a portion of the water in the resulting ammonium nitrate solution is evaporated using the reaction heat. As a result, more steam is needed to evaporate the solution and melt it sufficiently to solidify it through granulation. The purpose of this work is to examine and contrast some fundamental ideas of industrial ammonium synthesis production processes using the exergy method to improve reaction heat utilization and, consequently, a decrease in the amount of imported steam utilized. the result of plants indicates that via improved low-temperature heat utilization and water recovery, there may be some chance to reduce the middle (1 – 1.3 MPa) pressure steam import. If the steam condensate is cleaned (ammonia and AN concentration is less than 10 ppm w/w), recycled to the water treatment plant, and then used as boiler feed water after polishing, the external energy losses can be lowered by roughly 20% [10].

v.   Coating methods for surface modification of ammonium nitrate:

Because ammonium nitrate (AN) is hygroscopic, its use as a propellant oxidizer is restricted. This review compiled the material that is currently accessible on several topics related to coating techniques used in ammonium nitrate surface modification to lessen hygroscopicity. Additionally, this study highlights the difficulties and recent developments around the physical, chemical, and encapsulating coating approaches used to modify the surface of ammonium nitrate to decrease its hygroscopicity.In addition, a thorough discussion of the coating materials, process parameters, and hygroscopicity test settings is included, along with an overview of the benefits and drawbacks of each coating technique. Our results showed that additional study is desperately needed to further lower the hygroscopicity, both in the investigation and development of AN's anti-hygroscopicity and in the mechanisms of surface modification by coating. As a result, this review is helpful to scientists working to increase the anti-hygroscopicity of ammonium salts [11].

vi.   Reduction of dust emission by monodisperse system technology for ammonium nitrate manufacturing:

 In the fertilizer industry, a common procedure called prilling is used to transform fertilizer melt into droplets that fall, cool, and solidify in a countercurrent air flow inside a prilling tower. The investigation examined the disintegration of liquid jets in the Rayleigh regime, where a mechanical vibration was applied to produce monodispersed particles, and the breakup of liquid jets subjected to a forced perturbation was studied. A high-speed camera took photos of the jet trajectory, breakup, and the formed drops. Based on a transient two-dimensional Navier-Stokes equation, a mathematical model for the liquid outflow conditions was created and analytically solved. Correlations between the vibrator's process parameters and the jet pressure, which define their disintegration mode, were found.o droplets using a vibratory granulator. The experimental findings were in good agreement with the theoretical predictions derived from the correlations. The experiment results were used to determine the vibration system's process parameter values and to test them in a monodispersed jet disintegration mode in the production setting. The generation of monodispersed particles was found to be significantly influenced by the vibration frequency. The granulator design based on this study produced prills with a narrower size range compared to the conventional granulators, which resulted in a significant reduction in dust emission, according to the results of experiments conducted in a commercial-sized plant [12].

vii.   Reverse osmosis treatment of condensate from ammonium nitrate production: insights into membrane performance:

 An essential fertilizer and industrial explosive is ammonium nitrate. To produce ammonium nitrate, a significant amount of nitrogen-rich condensate must be treated before being released into the environment. The purpose of this study is to characterize how well various RO membranes perform in terms of condensate concentration for ammonium nitrate recovery and adherence to treated water discharge regulations. Results in this study show that through appropriate membrane selection, over 90% rejection of ammonium nitrate can be achieved by Reverse

Osmosis (RO) filtration. Using RO (which is highly compact and efficient) to enrich ammonium nitrate in the condensate would significantly reduce the size of the evaporation separator for ammonia recovery. The results also highlight the importance of membrane selection for this application. Results reported here suggest that a low-pressure RO membrane For the diluted condensate, (e.g.ESPA2) is more appropriate, but a high-pressure RO membrane (e.g. SW30) is recommended for the concentrated condensate to ensure adequate ammonia and nitrate rejection. Key operating parameters that affected ammonia and nitrate rejections were temperature, pH of the feed solution, applied pressure (or water flux), and the initial concentration of ammonium nitrate in the condensate The impact of operating conditions on ammonia and nitrate rejections was more profound for low-pressure (thus high flux) than high-pressure RO membranes. There is no indication of membrane fouling in an extended filtration experiment. Results from this study are useful for the integration of a compact RO system to ammonium nitrate manufacturing for pollution prevention and improving product yield. Operating conditions had a greater effect on ammonia and nitrate rejections for low-pressure RO membranes (i.e.high flux) than high-pressure RO membranes. There is no indication of membrane fouling in an extended filtering experiment. The study's findings can be applied to the production of ammonium nitrate by integrating a small RO system to reduce pollution and increase product yield [13].

3. AMMONIUM NITRATE PRODUCTION PROCESS

The ammonium nitrate plant consists of the wet part with the following equipment as shown in Figure 1. The ammonium nitrate plant consists of the neutralization and the concentration section. Both units are operating under partial vacuum conditions.
The Ammonium Nitrate neutralization as a proprietary process as well as the concentration represents a reliable and well-proven technology [14].
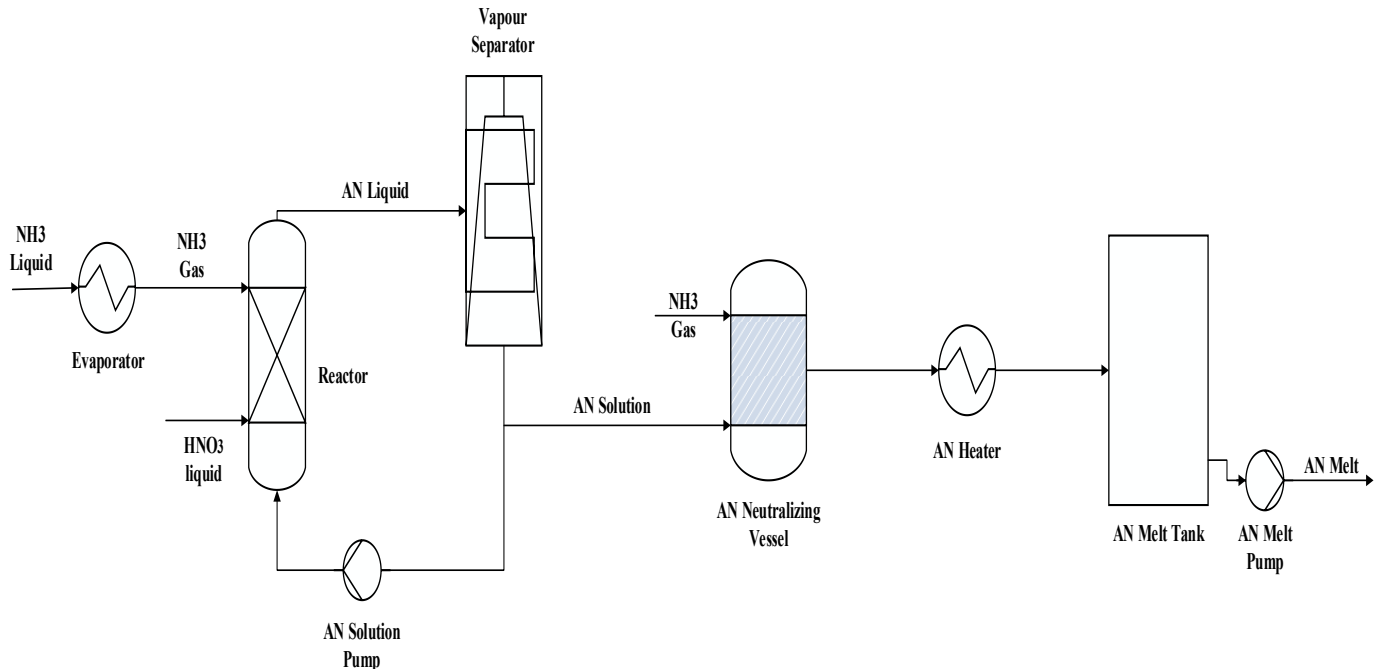

Figure 1: Ammonium Nitrate Production Process.

viii.   Process description

Ammonium nitrate is produced from the two initial media Nitric acid and Ammonia. The nitric acid is delivered from the HNO_3, plant as an aqueous solution of 60% wt. and a temperature of about 122 °C. Ammonia is supplied as liquid and must be vaporized and preheated to approx. 60 °C before neutralization.

The ammonium nitrate solution is formed by the reaction of the aqueous nitric acid with the gaseous ammonia according to the following equation:

NH_3 (gas) + HNO_3 (aqueous) → NH_4NO_3 (aqueous) + H_R ,(Equation 2)

The reaction is exothermic and the reaction heat for anhydrous NH_4NO_3 is

H_R = 1821 KJ/Kg "at 25 °C and 1 bar".

Ammonium nitrate is obtained as an aqueous solution. The reaction takes place in a forced circulation stream of already formed AN solution which is cooled down by flash evaporation. This is done to keep the reaction temperature under control and to keep the reaction temperature at a low level. During the reaction the water, introduced into the AN solution via the aqueous nitric acid, is partly vaporized employing the reaction heat in a flash evaporation effect. Through this an ammonium nitrate concentration of approx. 92 % wt. will be achieved. For maintaining the correct pH value of ammonium nitrate, at some places, ammonia Liquid is admixed into the AN solution / melt.

This acid is injected into the AN Neutralizer. Ammonia is supplied as liquid and must be vaporized in the ammonia evaporator. The ammonia Liquid is led to the AN Neutralizer.

The reaction heat is buffered in circulating AN solution and the solution flashes through an orifice into the cyclonic Vapor Separator. The solution cools down. The flashing of the AN solution increases the concentration to about 92 wt % of AN. By natural overflow, it passes into the AN Neutralizing Vessel for NH_3 surplus adjustment, which is controlled by pH value The alkaline solution passes via gravity to the AN concentration section.

The solution is fed to the AN Evaporator. In the evaporator, the solution is heated by steam and the water is evaporated to achieve the AN temperature and concentration required. The evaporator is heated to keep the temperature inside the evaporator below the critical temperature at which decomposition will begin, the steam is to be saturated first. The strength of the melt is adjustable over a certain range [14].

i.   NH3 and HNO3 feed and pH controls

To minimize nitrogen losses, the ammonium nitrate solution circulation in the AN neutralization loop system is kept slightly acidic, but as close to the neutral point as possible. The amount of gaseous NH_3 is adjusted by the controller (master) according to the desired load of the unit. The HNO_3, feed is automatically admixed via the ratio flow controller (slave). A cascade pH controller adjusts changes of HNO_3/NH_3, ratio [14].

ii.   Vapour separator

Before flashing in the orifice there is no boiling in the reaction loop. Downstream the orifice, the mixture of vapor and solution enters a cyclonic separator inlet. The centrifugal movement results in a good liquid separation. However, some fine droplets of solution are still entrained. These droplets are caught on the integrated vapor scrubbing trays [15].

iii.   Neutralisation

The reaction between nitric acid and gaseous ammonia takes place in a forced stream of already formed AN solution which is cooled down by flash evaporation into a vacuum pressure vapor system.

The temperature rises in the neutralizer, the reaction section being equipped with a titanium/titanium plated tube bundle.

The HNO_3 is injected into the circulated AN stream by several nozzles (contact-free), not utilizing a maintenance-intensive nitric acid sparger. Therefore, there is an issue of AN-solution entering a sparger that still contains nitric acid e.g., during a shut-down, which could cause a safety issue. Also, HNO_3, sparger corrosion problems are effectively avoided and the system can be thoroughly flushed at a system trip

After homogenization, the AN-HNO$_3$, the mixture enters the NH$_3$, sparger. Gaseous NH$_3$ is injected via many fine holes for a smooth reaction without local overheating, formation of steam bubbles, or large NH$_3$, bubbles. Due to this design issues of sensitized low-density areas are avoided and together with a downstream mixing zone an ammonia efficiency of 100% is achieved This reduces the total nitrogen losses because NH$_3$, contains 82 %wt. of nitrogen, but nitric acid only 22 %wt [14], [15].

iv.   Ammonium nitrate evaporation

A Falling Film Evaporator (FFE) is used to further concentrate the AN solution before prilling. The FFE operates with a short product residence time and only a small liquid hold-up. As no insoluble components are present in the AN solution a fouling/scaling of the exchanger tubes is not expected.

The AN solution from the neutralization is fed into the liquid distributor at the top of the FFE. Condensing live steam heats the AN solution, water is evaporated for a concentration of approx. 96 wt %. Due to the vacuum pressure of approx. 400 mbar absolute on the process side the AN temperature is kept at a low temperature of below 160 °C. The resulting AN melt flows via gravity into the AN Melt tank [15].

4.   SIMULATION OF AMMONIUM NITRATE PLANT BY USING ASPEN HYSIS

Two methods were used in calculating the mass balance and energy balance for the process which is:

i) Manual calculation

ii) HYSYS simulation

HYSYS program was used to see whether the design could be run or not. Using Hysys the calculation of the process was calculated automatically when the parameter that was needed was inserted. Then if the parameter that was inserted is logic so HYSYS program can calculate the result and the equipment can converge. If the data that was inserted was illogical the equipment cannot converge and the calculation cannot be done. The back of Figure 2 shows the simulation of an AN plant using HYSYS [16].
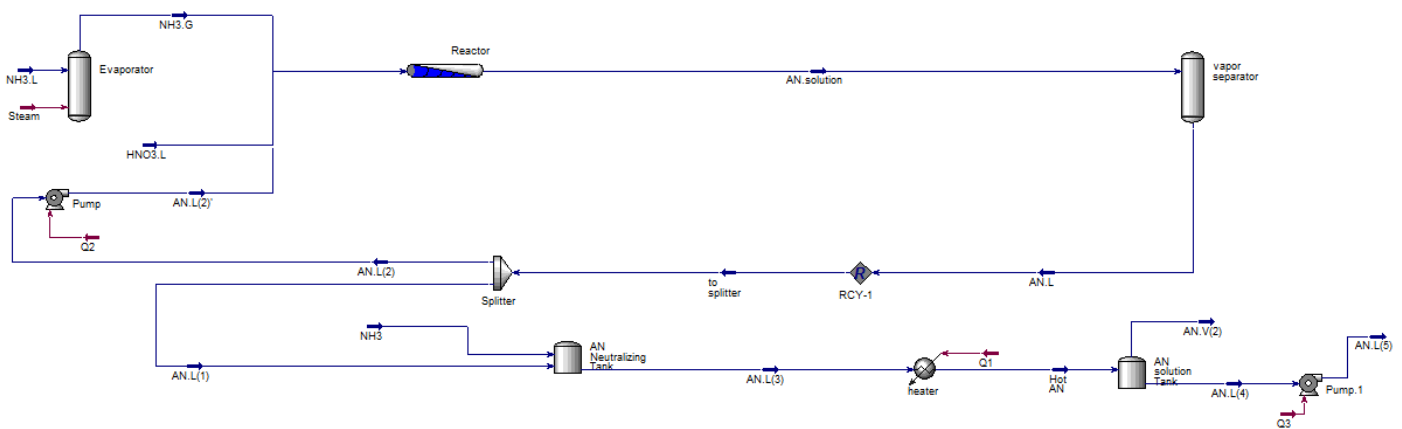

Figure 2: Simulation of AN Plant.

ix.   Conditions and compositions of input and output from equipment
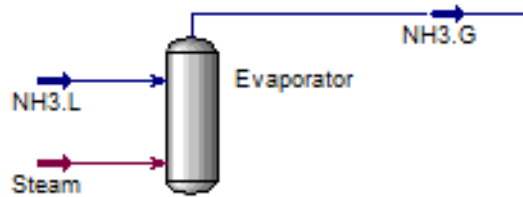
v. Evaporator

Figure 3: Simulation of Evaporator.

The NH_3 Liquid is fed to the Evaporator and is heated by steam from (-24.56 C☐ to 60☐ C☐) and the water is evaporated to achieve the AN temperature and concentration required.

Figure **3** Shown The input and output from the Evaporator. The Conditions and Compositions of the (NH_3.L) Stream that Entered to Evaporator had Following as Shown in
Table 1 and Table 2.(NH_3.G) Conditions and Compositions that Comes Out of Evaporator Shown in Table 3 and Table 4.

Table 1: NH_3.L Conditions.

Stream Name	NH3.L	Liquid Phase	Vapour Phase
Vapour / Phase Fraction	0.0000	1.0000	0.0000
Temperature [C]	-24.56	-24.56	-24.56
Pressure [kPa]	430.0	430.0	430.0
Molar Flow [kgmole/h]	552.1	552.1	0.0000
Mass Flow [kg/h]	9402	9402	0.0000
Std Ideal Liq Vol Flow [m3/h]	15.26	15.26	0.0000
Molar Enthalpy [kJ/kgmole]	-6.885e+004	-6.885e+004	-6.873e+004
Molar Entropy [kJ/kgmole-C]	67.17	67.17	67.16
Heat Flow [kJ/h]	-3.801e+007	-3.801e+007	0.0000
Liq Vol Flow @Std Cond [m3/h]	16.40	16.40	0.0000
Fluid Package	Basis-2		
Utility Type			

Table 2:NH$_3$.L Composition.

	Mole Fractions	Liquid Phase
Ammonia	**0.9995**	0.9995
H2O	**0.0005**	0.0005
HNO3	**0.0000**	0.0000
NH4 NO3*	**0.0000**	0.0000
Total	1.00000	

Table 3:NH$_3$.G Conditions.

Stream Name	NH3.G	Vapour Phase	Liquid Phase
Vapour / Phase Fraction	1.0000	1.0000	0.0000
Temperature [C]	**60.00**	60.00	60.00
Pressure [kPa]	430.0	430.0	430.0
Molar Flow [kgmole/h]	552.1	552.1	0.0000
Mass Flow [kg/h]	9402	9402	0.0000
Std Ideal Liq Vol Flow [m3/h]	15.26	15.26	0.0000
Molar Enthalpy [kJ/kgmole]	-4.478e+004	-4.478e+004	-8.235e+004
Molar Entropy [kJ/kgmole-C]	162.1	162.1	91.89
Heat Flow [kJ/h]	-2.472e+007	-2.472e+007	0.0000
Liq Vol Flow @Std Cond [m3/h]	16.40	16.40	0.0000
Fluid Package	Basis-2		
Utility Type			

Table 4:NH_3.G Gas Composition.

	Mole Fractions	
Ammonia	0.9995	
H2O	0.0005	
HNO3	0.0000	
NH4 NO3*	0.0000	
Total	1.00000	

vi.   Reactor

There are Three Streams Fed to The Reactor and the Desired Product exists from the Reactor as   Shown in Figure 4.
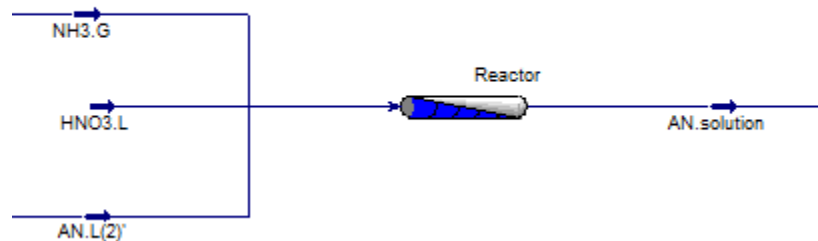

Figure 4:Simulation of Reactor.

The Conditions and Compositions of (NH_3.G) that Entered to Reactor Shown in(Table 3&Table 4)(HNO_3.L&AN.L(2)') Conditions and Compositions that Entered to Reactor Shown in (

Table **5**&Table 6) and (Table 7&
Table **8**).

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Table 5:Conditions of HNO$_3$.L.

Stream Name	HNO3.L	Liquid Phase	Aqueous Phase	Vapour Phase
Vapour / Phase Fraction	0.0000	0.6724	0.3276	0.0000
Temperature [C]	122.9	122.9	122.9	122.9
Pressure [kPa]	630.0	630.0	630.0	630.0
Molar Flow [kgmole/h]	1203	809.0	394.2	0.0000
Mass Flow [kg/h]	5.777e+004	5.051e+004	7262	0.0000
Std Ideal Liq Vol Flow [m3/h]	40.41	33.22	7.199	0.0000
Molar Enthalpy [kJ/kgmole]	-2.041e+005	-1.685e+005	-2.772e+005	-2.021e+005
Molar Entropy [kJ/kgmole-C]	64.32	58.19	76.90	70.79
Heat Flow [kJ/h]	-2.456e+008	-1.363e+008	-1.093e+008	0.0000
Liq Vol Flow @Std Cond [m3/h]	57.66	49.85	7.187	0.0000
Fluid Package	Basis-2			
Utility Type				

Table 6:Compositions of HNO3.L.

	Mole Fractions	Liquid Phase	Aqueous Phase	Vapour Phase
Ammonia	0.0000	0.0000	0.0000	0.0000
H2O	0.3333	0.0128	0.9910	0.3445
HNO3	0.6667	0.9872	0.0090	0.6555
NH4 NO3*	0.0000	0.0000	0.0000	0.0000

Table 7:Conditions of AN.L(2)'.

Stream Name	AN.L(2)'	Liquid Phase	Aqueous Phase
Vapour / Phase Fraction	0.0000	0.6658	0.3342
Temperature [C]	-37.83	-37.83	-37.83
Pressure [kPa]	230.0	230.0	230.0
Molar Flow [kgmole/h]	1.599e+004	1.065e+004	5344
Mass Flow [kg/h]	8.921e+005	7.953e+005	9.682e+004
Std Ideal Liq Vol Flow [m3/h]	574.8	478.0	96.75
Molar Enthalpy [kJ/kgmole]	-2.246e+005	-1.924e+005	-2.889e+005
Molar Entropy [kJ/kgmole-C]	-202.4	-325.2	42.20
Heat Flow [kJ/h]	-3.592e+009	-2.048e+009	-1.544e+009
Liq Vol Flow @Std Cond [m3/h]	1506	1380	95.71
Fluid Package	Basis-2		
Utility Type			

Table 8:Compositions of AN.L(2)'.

	Mole Fractions	Liquid Phase	Aqueous Phase
Ammonia	0.0000	0.0000	0.0000
H2O	0.3335	0.0000	0.9978
HNO3	0.2080	0.3113	0.0022
NH4 NO3*	0.4585	0.6887	0.0000

Ammonium Nitrate that Exists from the Reactor is Fed to the Vapor Separator to Separate Vapor from Liquid and then (AN.L) is OutPut from the Separator as a Resycle to The Reactor. The Vapor is used as a Purge as Shown in Figure 5.
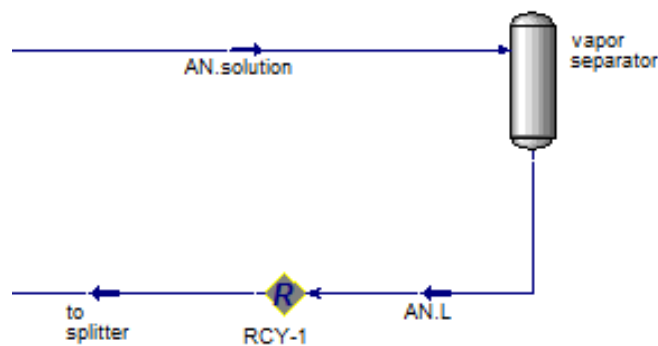
vii.   Vapor separator

Figure 5:Simulation Of Vapor Separator.

The Conditions and Compositions of (AN.Solution) that were fed to the Vapor Separator are Shown in(

Table **9**&Table 10). (AN.L) Conditions and Compositions that Exist from the Vapor Separator Shown in (Table 11 and Table 12).

Table 9:AN.Solution Conditions.

Stream Name	AN.solution	Liquid Phase	Aqueous Phase	Vapour Phase
Vapour / Phase Fraction	0.0000	0.6658	0.3342	0.0000
Temperature [C]	-37.83	-37.83	-37.83	-37.83
Pressure [kPa]	210.0	210.0	210.0	210.0
Molar Flow [kgmole/h]	1.719e+004	1.145e+004	5746	0.0000
Mass Flow [kg/h]	9.593e+005	8.552e+005	1.041e+005	0.0000
Std Ideal Liq Vol Flow [m3/h]	618.1	514.0	104.0	0.0000
Molar Enthalpy [kJ/kgmole]	-2.246e+005	-1.924e+005	-2.889e+005	-2.792e+005
Molar Entropy [kJ/kgmole-C]	-202.4	-325.2	42.20	34.79
Heat Flow [kJ/h]	-3.862e+009	-2.202e+009	-1.660e+009	0.0000
Liq Vol Flow @Std Cond [m3/h]	1619	1484	102.9	0.0000
Fluid Package	Basis-2			
Utility Type				

Table 10: AN.Solution Composition.

	Mole Fractions	Liquid Phase	Aqueous Phase	Vapour Phase
Ammonia	0.0000	0.0000	0.0000	0.0000
H2O	0.3335	0.0000	0.9978	0.9022
HNO3	0.2080	0.3113	0.0022	0.0953
NH4 NO3*	0.4585	0.6887	0.0000	0.0025

Table 11:AN.L Conditions.

Stream Name	AN.L	Liquid Phase	Aqueous Phase	Vapour Phase
Vapour / Phase Fraction	0.0000	0.6658	0.3342	0.0000
Temperature [C]	-37.84	-37.84	-37.84	-37.84
Pressure [kPa]	210.0	210.0	210.0	210.0
Molar Flow [kgmole/h]	1.719e+004	1.145e+004	5746	0.0000
Mass Flow [kg/h]	9.593e+005	8.552e+005	1.041e+005	0.0000
Std Ideal Liq Vol Flow [m3/h]	618.1	514.0	104.0	0.0000
Molar Enthalpy [kJ/kgmole]	-2.246e+005	-1.924e+005	-2.889e+005	-2.492e+005
Molar Entropy [kJ/kgmole-C]	-202.4	-325.2	42.20	8.329
Heat Flow [kJ/h]	-3.862e+009	-2.202e+009	-1.660e+009	0.0000
Liq Vol Flow @Std Cond [m3/h]	1619	1484	102.9	0.0000
Fluid Package	Basis-2			
Utility Type				

Table 12: AN.L Compositions.

	Mole Fractions	Liquid Phase
Ammonia	0.0000	0.0000
H2O	0.3335	0.0000
HNO3	0.2080	0.3113
NH4 NO3*	0.4585	0.6887

viii.   Splitter

(AN.L) that Comes from the Vapor Separator is fed to the Splitter,(AN.L(2)&AN.L(1)) Exist from the Splitter and (AN.L(2)) is fed to Reactor as a Resycle by Ratio (14/15) While (AN.L(1)) is Fed to AN Neutralizing Tank by Ratio (1/15).
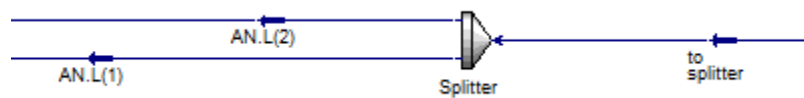

Figure 6:Simulation of Splitter.

The Product that Comes from Vapor Separator (To Splitter) had a Following Conditions and Compositions Shown in (Table 13&Table 14), The Conditions and Compositions for the output of the Splitter are Shown in (

Table **15**, Table 16, Table 17, and Table 18).

Table 13: Conditions of (To Splitter).

Stream Name	to splitter	Liquid Phase	Aqueous Phase
Vapour / Phase Fraction	0.0000	0.6658	0.3342
Temperature [C]	-37.84	-37.84	-37.84
Pressure [kPa]	210.0	210.0	210.0
Molar Flow [kgmole/h]	1.719e+004	1.145e+004	5746
Mass Flow [kg/h]	9.593e+005	8.552e+005	1.041e+005
Std Ideal Liq Vol Flow [m3/h]	618.1	514.0	104.0
Molar Enthalpy [kJ/kgmole]	-2.246e+005	-1.924e+005	-2.889e+005
Molar Entropy [kJ/kgmole-C]	-202.4	-325.2	42.20
Heat Flow [kJ/h]	-3.862e+009	-2.202e+009	-1.660e+009
Liq Vol Flow @Std Cond [m3/h]	1619	1484	102.9
Fluid Package	Basis-2		
Utility Type			

Table 14:Compositions of (To Splitter).

	Mole Fractions	Liquid Phase	Aqueous Phase
Ammonia	0.0000	0.0000	0.0000
H2O	0.3335	0.0000	0.9978
HNO3	0.2080	0.3113	0.0022
NH4 NO3*	0.4585	0.6887	0.0000

Table 15: Conditions of (AN.L(2)).

Stream Name	AN.L(2)	Liquid Phase	Aqueous Phase
Vapour / Phase Fraction	0.0000	0.6658	0.3342
Temperature [C]	-37.84	-37.84	-37.84
Pressure [kPa]	210.0	210.0	210.0
Molar Flow [kgmole/h]	1.599e+004	1.065e+004	5344
Mass Flow [kg/h]	8.921e+005	7.953e+005	9.682e+004
Std Ideal Liq Vol Flow [m3/h]	574.8	478.0	96.75
Molar Enthalpy [kJ/kgmole]	-2.246e+005	-1.924e+005	-2.889e+005
Molar Entropy [kJ/kgmole-C]	-202.4	-325.2	42.20
Heat Flow [kJ/h]	-3.592e+009	-2.048e+009	-1.544e+009
Liq Vol Flow @Std Cond [m3/h]	1506	1380	95.71
Fluid Package	Basis-2		
Utility Type			

Table 16: Compositions of (AN.L(2)).

	Mole Fractions	Liquid Phase	Aqueous Phase
Ammonia	0.0000	0.0000	0.0000
H2O	0.3335	0.0000	0.9978
HNO3	0.2080	0.3113	0.0022
NH4 NO3*	0.4585	0.6887	0.0000

Table 17: Conditions of (AN.L(1)).

Stream Name	AN.L(1)	Liquid Phase	Aqueous Phase
Vapour / Phase Fraction	0.0000	0.6658	0.3342
Temperature [C]	-37.84	-37.84	-37.84
Pressure [kPa]	210.0	210.0	210.0
Molar Flow [kgmole/h]	1204	801.3	402.3
Mass Flow [kg/h]	6.715e+004	5.986e+004	7287
Std Ideal Liq Vol Flow [m3/h]	43.26	35.98	7.282
Molar Enthalpy [kJ/kgmole]	-2.246e+005	-1.924e+005	-2.889e+005
Molar Entropy [kJ/kgmole-C]	-202.4	-325.2	42.20
Heat Flow [kJ/h]	-2.704e+008	-1.542e+008	-1.162e+008
Liq Vol Flow @Std Cond [m3/h]	113.3	103.9	7.204
Fluid Package	Basis-2		
Utility Type			

Table 18: Compositions of (AN.L(1)).

	Mole Fractions	Liquid Phase	Aqueous Phase
Ammonia	0.0000	0.0000	0.0000
H2O	0.3335	0.0000	0.9978
HNO3	0.2080	0.3113	0.0022
NH4 NO3*	0.4585	0.6887	0.0000

ix. Pump

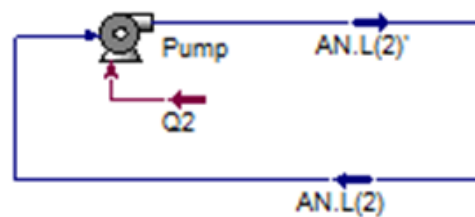In the Pump, The Pressure of (AN.L(2)) Stream is Increased from 210 KPa to 230 KPa. As Shown in Figure 7.

Figure 7: Simulation of Pump.

The Conditions and Compositions of (AN.L(2)) Stream Shown in

Table **15** and Table 16, While The Conditions and Compositions of (AN.L(2)') Stream Shown in Table 19 and

Table **20**.

Table 19: Conditions of (AN.L(2)').

Stream Name	AN.L(2)'	Liquid Phase	Aqueous Phase
Vapour / Phase Fraction	0.0000	0.6658	0.3342
Temperature [C]	-37.83	-37.83	-37.83
Pressure [kPa]	230.0	230.0	230.0
Molar Flow [kgmole/h]	1.599e+004	1.065e+004	5344
Mass Flow [kg/h]	8.921e+005	7.953e+005	9.682e+004
Std Ideal Liq Vol Flow [m3/h]	574.8	478.0	96.75
Molar Enthalpy [kJ/kgmole]	-2.246e+005	-1.924e+005	-2.889e+005
Molar Entropy [kJ/kgmole-C]	-202.4	-325.2	42.20
Heat Flow [kJ/h]	-3.592e+009	-2.048e+009	-1.544e+009
Liq Vol Flow @Std Cond [m3/h]	1506	1380	95.71
Fluid Package	Basis-2		
Utility Type			

Table 20: Compositions of (AN.L(2)').

	Mole Fractions	Liquid Phase	Aqueous Phase
Ammonia	0.0000	0.0000	0.0000
H2O	0.3335	0.0000	0.9978
HNO3	0.2080	0.3113	0.0022
NH4 NO3*	0.4585	0.6887	0.0000

x. Ammonium nitrate neutralizing tank

By natural overflow, it passes into the AN Neutralizing Vessel for NH_3 surplus adjustment, which is controlled by pH - value The alkaline solution passes via gravity to the AN concentration section as Shown in Figure 8.
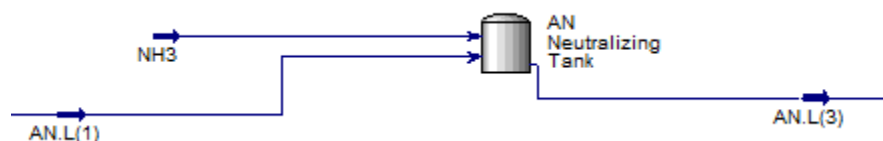

Figure 8: Simulation of Ammonium Nitrate Neutralizing Tank.

The Conditions and Compositions of (NH$_3$) Stream Shown in (Table 21:NH3 Conditions&

Table 22:NH3 Composition While The Conditions and Compositions of (AN.L(1)) Shown in (Table 17: Conditions of (AN.L(1))&Table 18), and AN.L(3) Conditions and Compositions Shown in (
Table **23**&Table 24).

Table 21:NH$_3$ Conditions.

Stream Name	NH3	Liquid Phase	Vapour Phase
Vapour / Phase Fraction	0.0000	1.0000	0.0000
Temperature [C]	60.00	60.00	60.00
Pressure [kPa]	4958	4958	4958
Molar Flow [kgmole/h]	1.687	1.687	0.0000
Mass Flow [kg/h]	29.00	29.00	0.0000
Std Ideal Liq Vol Flow [m3/h]	4.397e-002	4.397e-002	0.0000
Molar Enthalpy [kJ/kgmole]	-9.911e+004	-9.911e+004	-6.046e+004
Molar Entropy [kJ/kgmole-C]	87.76	87.76	96.82
Heat Flow [kJ/h]	-1.672e+005	-1.672e+005	0.0000
Liq Vol Flow @Std Cond [m3/h]	4.332e-002	4.332e-002	0.0000
Fluid Package	Basis-2		
Utility Type			

Table 22:NH$_3$ Composition.

	Mole Fractions	Liquid Phase	Vapour Phase
Ammonia	0.8355	0.8355	0.9977
H2O	0.1645	0.1645	0.0023
HNO3	0.0000	0.0000	0.0000
NH4 NO3*	0.0000	0.0000	0.0000

Table 23:AN.L(3) Conditions.

Stream Name	AN.L(3)	Liquid Phase	Aqueous Phase	Vapour Phase
Vapour / Phase Fraction	0.0000	0.6649	0.3351	0.0000
Temperature [C]	-37.42	-37.42	-37.42	-37.42
Pressure [kPa]	210.0	210.0	210.0	210.0
Molar Flow [kgmole/h]	1205	801.3	403.9	0.0000
Mass Flow [kg/h]	6.718e+004	5.986e+004	7314	0.0000
Std Ideal Liq Vol Flow [m3/h]	43.31	35.98	7.325	0.0000
Molar Enthalpy [kJ/kgmole]	-2.245e+005	-1.924e+005	-2.882e+005	-2.385e+005
Molar Entropy [kJ/kgmole-C]	-201.9	-325.1	42.44	13.07
Heat Flow [kJ/h]	-2.705e+008	-1.541e+008	-1.164e+008	0.0000
Liq Vol Flow @Std Cond [m3/h]	113.4	103.9	7.241	0.0000
Fluid Package	Basis-2			
Utility Type				

Table 24:AN.L(3) Compositions.

	Mole Fractions	Liquid Phase	Aqueous Phase	Vapour Phase
Ammonia	0.0012	0.0000	0.0035	0.0601
H2O	0.3333	0.0000	0.9944	0.5646
HNO3	0.2077	0.3114	0.0022	0.3576
NH4 NO3*	0.4578	0.6886	0.0000	0.0177

xi.   Heater

AN.L(3) that comes out from the Ammonium Nitrate Neutralizing Tank is Fed to Heater to Heating it Before Entering to AN solution Tank as Shown in Figure 9: Heater Simulation.
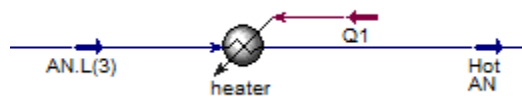

Figure 9: Heater Simulation.

AN.L(3) Conditions and Compositions Shown in (
Table **23**&Table 24), While the Conditions and Compositions of Hot AN Shown in (

Table **25**&
Table **26**).

Table 25: Hot AN Conditions.

Stream Name	Hot AN	Vapour Phase	Liquid Phase
Vapour / Phase Fraction	0.5711	0.5711	0.4289
Temperature [C]	152.0	152.0	152.0
Pressure [kPa]	210.0	210.0	210.0
Molar Flow [kgmole/h]	1205	688.3	516.9
Mass Flow [kg/h]	6.718e+004	2.665e+004	4.053e+004
Std Ideal Liq Vol Flow [m3/h]	43.31	19.54	23.76
Molar Enthalpy [kJ/kgmole]	-1.882e+005	-1.926e+005	-1.824e+005
Molar Entropy [kJ/kgmole-C]	-101.1	122.7	-399.2
Heat Flow [kJ/h]	-2.269e+008	-1.326e+008	-9.426e+007
Liq Vol Flow @Std Cond [m3/h]	113.4	33.49	78.25
Fluid Package	Basis-2		
Utility Type			

Table 26: Hot AN Composition.

	Mole Fractions	Vapour Phase	Liquid Phase
Ammonia	0.0012	0.0020	0.0000
H2O	0.3333	0.5794	0.0055
HNO3	0.2077	0.3083	0.0738
NH4 NO3*	0.4578	0.1103	0.9207

xii.   Ammonium nitrate solution tank

Hot AN Enter an Ammonium Nitrate solution Tank To Vaporise Water And Nitric Acid To Produce AN as a Liquid Solution, While All vapors That Output from the Ammonium Nitrate solution Tank are used as a Purge, Figure 10 shows this.
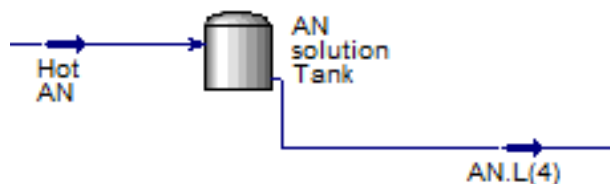

Figure 10: AN solution Tank Simulation.

Conditions of (AN.L(4)) and Compositions Shown in

Table **27**&

Table **28**.

Table 27:Conditions of (AN.L(4)).

Stream Name	AN.L(4)	Vapour Phase	Liquid Phase
Vapour / Phase Fraction	0.0000	0.0000	1.0000
Temperature [C]	152.0	152.0	152.0
Pressure [kPa]	210.0	210.0	210.0
Molar Flow [kgmole/h]	516.9	0.0000	516.9
Mass Flow [kg/h]	4.053e+004	0.0000	4.053e+004
Std Ideal Liq Vol Flow [m3/h]	23.76	0.0000	23.76
Molar Enthalpy [kJ/kgmole]	-1.824e+005	-1.926e+005	-1.824e+005
Molar Entropy [kJ/kgmole-C]	-399.2	122.7	-399.2
Heat Flow [kJ/h]	-9.426e+007	0.0000	-9.426e+007
Liq Vol Flow @Std Cond [m3/h]	78.25	0.0000	78.25
Fluid Package	Basis-2		
Utility Type			

Table 28:Composition of (AN.L(4)).

	Mole Fractions	Vapour Phase	Liquid Phase
Ammonia	0.0000	0.0020	0.0000
H2O	0.0055	0.5794	0.0055
HNO3	0.0738	0.3083	0.0738
NH4 NO3*	0.9207	0.1103	0.9207

xiii.   Pump.1

In the Pump.1 The Pressure of (AN.L(4)) Stream is Increased from 210 KPa to 230 KPa. As Shown in Figure 11.
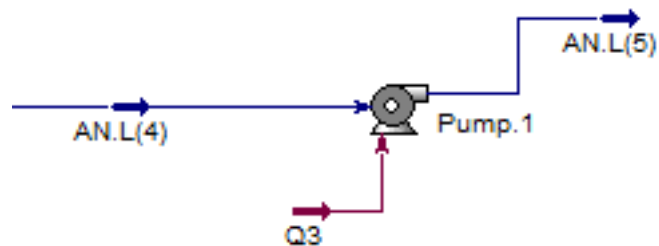

Figure 11:Pump.1 Simulation.

Conditions of (AN.L(5)) and Compositions Shown in Table 29&

Table **30**.

Table 29: Conditions of (AN.L(5)).

Stream Name	AN.L(5)	Liquid Phase
Vapour / Phase Fraction	0.0000	1.0000
Temperature [C]	152.0	152.0
Pressure [kPa]	230.0	230.0
Molar Flow [kgmole/h]	516.9	516.9
Mass Flow [kg/h]	4.053e+004	4.053e+004
Std Ideal Liq Vol Flow [m3/h]	23.76	23.76
Molar Enthalpy [kJ/kgmole]	-1.824e+005	-1.824e+005
Molar Entropy [kJ/kgmole-C]	-399.2	-399.2
Heat Flow [kJ/h]	-9.426e+007	-9.426e+007
Liq Vol Flow @Std Cond [m3/h]	78.25	78.25
Fluid Package	Basis-2	
Utility Type		

Table 30: Compositions of (AN.L(5)).

	Mass Flows	Liquid Phase
Ammonia	0.1230	0.1230
H2O	51.1548	51.1548
HNO3	2403.1004	2403.1004
NH4 NO3*	38071.9555	38071.9555

x.   Material balance calculations by using HYSYS

Material balances are the basis of process design. A material balance taken over the complete process will determine the quantities of raw materials required and the products produced. Balances over individual process units set the process stream flows and compositions. All Data Calculated by HYSYS.

xiv.   Evaporator

Table 31:Material balance for Evaporator.

	input	output
Name	NH$_3$.L	NH$_3$.G
Mass Flow [kg/h]	9402	9402
Molar Flow [kgmole/h]	552.1	552.1

xv.   Plug flow reactor

Table 32: Material Balance for Reactor.

Name	input			output
	NH₃.G	HNO₃.L	AN.L(2)'	AN.solution
Mass Flow [kg/h]	9402	5.777e+004	8.921e+005	9.593e+005
Molar Flow [kgmole/h]	552.1	1203	1.599e+004	1.719e+004

xvi.   Vapor separator

Table 33:Material Balance for VaPor Separator.

Name	input	output
	AN.solution	AN.L(to splitter)
Mass Flow [kg/h]	9.593e+005	9.593e+005
Molar Flow [kgmole/h]	1.719e+004	1.719e+004

xvii.   Splitter

Table 34: Material Balance for Splitter.

Name	input	output	
	to splitter	AN.L(1)	AN.L(2)
Mass Flow [kg/h]	9.593e+005	6.715e+004	8.921e+005
Molar Flow [kgmole/h]	1.719e+004	1204	1.599e+004

xviii.   Pump

Table 35: Material Balance for Pump.

Name	input	output
	AN.L(2)	AN.L(2)'
Mass Flow [kg/h]	8.921e+005	8.921e+005
Molar Flow [kgmole/h]	1.599e+004	1.599e+004

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xix.   AN neutralizing tank

Table 36: Material Balance for AN Neutralizing Tank.

Name	input		output
	AN.L(1)	NH$_3$	AN.L(3)
Mass Flow [kg/h]	6.715e+004	29	6.718e+004
Molar Flow [kgmole/h]	1204	1.687	1205

xx.   Heater

Table 37: Material Balance for Heater.

Name	input	output
	AN.L(3)	Hot AN
Mass Flow [kg/h]	6.718e+004	6.718e+004
Molar Flow [kgmole/h]	1205	1205

xxi.   AN solution tank

Table 38: Material Balance of AN Solution Tank.

Name	input	output
	Hot AN	AN.L(4)
Mass Flow [kg/h]	6.718e+004	4.053e+004
Molar Flow [kgmole/h]	1205	516

xxii.   Pump.1

Table 39: Material Balance for Pump.1.

Name	input	output
	AN.L(4)	AN.L(5)
Mass Flow [kg/h]	4.053e+004	4.053e+004
Molar Flow [kgmole/h]	516	516

xi.   Energy balance calculations by using hysys

As with mass, energy can be considered to be separately conserved in all but nuclear processes. The conservation of energy, however, differs from that of mass in that energy can be generated (or consumed) in a chemical process. Material can change form, and new molecular species can be formed by chemical reactions, but the total mass flow into a process unit must be equal to the flow out at the steady state. The same is not true of energy. In hysys Energy Balance is Calculated To Evaluate Heat Flow for the Steam of Evaporator, Pumps, and Heater.   Table 40 showing The Energy Balance Calculations for Ammonium Nitrate Plant.

Table 40:Energy Balance Calculations.

Name	Steam	Q1	Q2	Q3
Heat Flow [kJ/h]	1.329e+007	4.368e+007	3.418e+004	2302

5. HAZOP STUDY

Table 41:HAZOP Study Of AN Plant.

Parameter	Guideword	Deviation	Causes	Consequence	Action
	None	- No Flow of liquid ammonia from the ammonia storage tank to ammonia evaporator	- Failure of valve - Failure of supply from storage tank - Manual isolation valve	- Level decrease in an evaporator - Pressure decrease in an evaporator	- Level low alarm - Pressure low alarm
	None	- No flow of ammonia gas from the ammonia evaporator to the neutralizer	- flow control valve closed	- Minor temperature increase in heater; no concern for heater	
	None	- No Flow of ammonia gas to the neutralizer	- Failure of control valve	- Wrong ratio of ammonia / nitric acid decrease of pH of ammonium nitrate solution could result in decomposition of ammonium nitrate and explosion	- Low-flow alarm - Low ratio alarm - Low ammonia flow switch
	None	- No flow of nitric acid to Neutralizer	- Failure of control valve	- Wrong ratio of ammonia / nitric acid decrease of pH of ammonium nitrate	- Low-flow alarm - Low ratio alarm - Low ammonia flow switch

				solution could result in decomposition of ammonium nitrate and explosion	
Flow	None	- No flow of ammonium nitrate solution via loop	- Failure of pump	- Temperature increase in neutralizer decomposition of ammonium nitrate possibly an explosion in neutralizer	- High/low current trip - Temperature high alarm
	None	- No flow of AN solution from the separator to the AN neutralizing vessel	- Neutralization is stopped - No feed from upstream system	- Temperature decrease in the vessel due heat loss	- Operation instruction for manual draining of neutralizing vessel
	None	- No Flow of AN solution from the AN solution tank evaporator	- Failure of pump - Failure of valve - Blockage of line due to crystallization	- Pump running to a closed system	- Min. flow line provided
	None	- No flow of steam to a heating coil of AN solution tank	- Failure of valve	- Temperature decrease in solution tank possible	- Temperature low alarm
	None	- No Flow of AN solution from to evaporator	- Failure of supply	- Reduced or no load to evaporator	- Low-level alarm
	None	- No flow of steam to evaporator	- Failure of steam supply	- No evaporation process disturbance in downstream system	- Pressure low alarm
	None	- No flow of AN melt from the pump	- Blockage of min. flow line due to crystallization	- Temperature increase in the pump if the discharge line is closed; decomposition of AN melt possible	- Low-flow alarm - Current low alarm
Temperature	High	- Higher temperature in ammonia evaporator	- High temperature of steam	- Temperature increase in ammonia heater	- Design temperature of ammonia heater 150°C (steam temperature max.150 °C)
	Low	- Lower temperature in ammonia heater	- Low temperature of steam	- Temperature decrease in ammonia heater	-Temperature low alarm
	High	- The higher temperature in AN solution loop	- Overload of neutralizer by feedstock	-Temperature increase in neutralizer	- Temperature high alarm
	Low	- The lower temperature in AN solution loop	- Lower pressure in the separator	- Forming of AN crystals in loop	- Temperature low alarm
	Low	- The lower temperature in AN solution tank	- Failure of temperature control	- Possible crystallization during standby operation of solution tank	- Temperature low alarm
	High	- The higher temperature in AN melts at the evaporator	- Failure of temperature/pressure control	- Higher concentration of AN melt	- Temperature high alarm - High alarm

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					concentration measurement
	Low	- The lower temperature in AN melts at evaporator	- Failure of temperature/pressure control	- Lower concentration of AN melt;	- Temperature low alarm - Low alarm concentration measurement
	High	- Higher temperature in AN melt tank	- Failure of temperature control	- Decomposition of AN melt after longer time of stand-by operation with decreased pH possible. explosion in tank possible	- Temperature high alarm - Temperature switch high
Pressure	High	- Higher pressure in ammonia evaporator	- Failure of pressure control - System blocked	- Pressure increases up to set pressure of pressure control of evaporator	- Design pressure of evaporator higher than max. possible pressure - Pressure high alarm
	Low	- Lower pressure in ammonia evaporator	- Failure of pressure control	- Operational disturbance and shut down of neutralization	- Pressure low alarm
	High	- Higher pressure in neutralizer	- Failure of pressure control	- Pressure increase within normal operation range	- Pressure high alarm - Temperature high alarm
	Low	- Lower pressure in AN melt tank	- AN melt feed line not sufficiently submerged	- Negative pressure in AN melt tank	- Open connection to final scrubber - Overflow line to Trench
Level	High	- Higher Level in ammonia evaporator	- Failure of level controller	- Overfilling of evaporator possible; liquid carry over to neutralization, release of ammonia gas to atmosphere possible	- Level high alarm - Level switch high
	Low	- Lower Level in ammonia evaporator	- Failure of level controller	- Pressure decreases in evaporator	- Pressure low alarm - Level low alarm
	High	- Higher Level of AN solution in separator	- Not possible due to open overflow line	- No consequence	
	Low	- Lower Level of AN solution in separator	- Separator not filled during startup of plant	- Dry running of pump	- Level low alarm - Level switch low
	Low	- Lower Level in AN solution tank	- Failure of supply of AN solution to tank	- Dry running of pump possible; possible damage to pump	- Level low alarm - Level switch low

6. EQUIPMENT SPACING

Equipment spacing is critical for ensuring the safe location of used equipment throughout the facility. For example, if an explosion occurs and equipment spacing is not considered, it may influence adjacent equipment and cause other serious difficulties. The spacing was demonstrated in Figure 12.
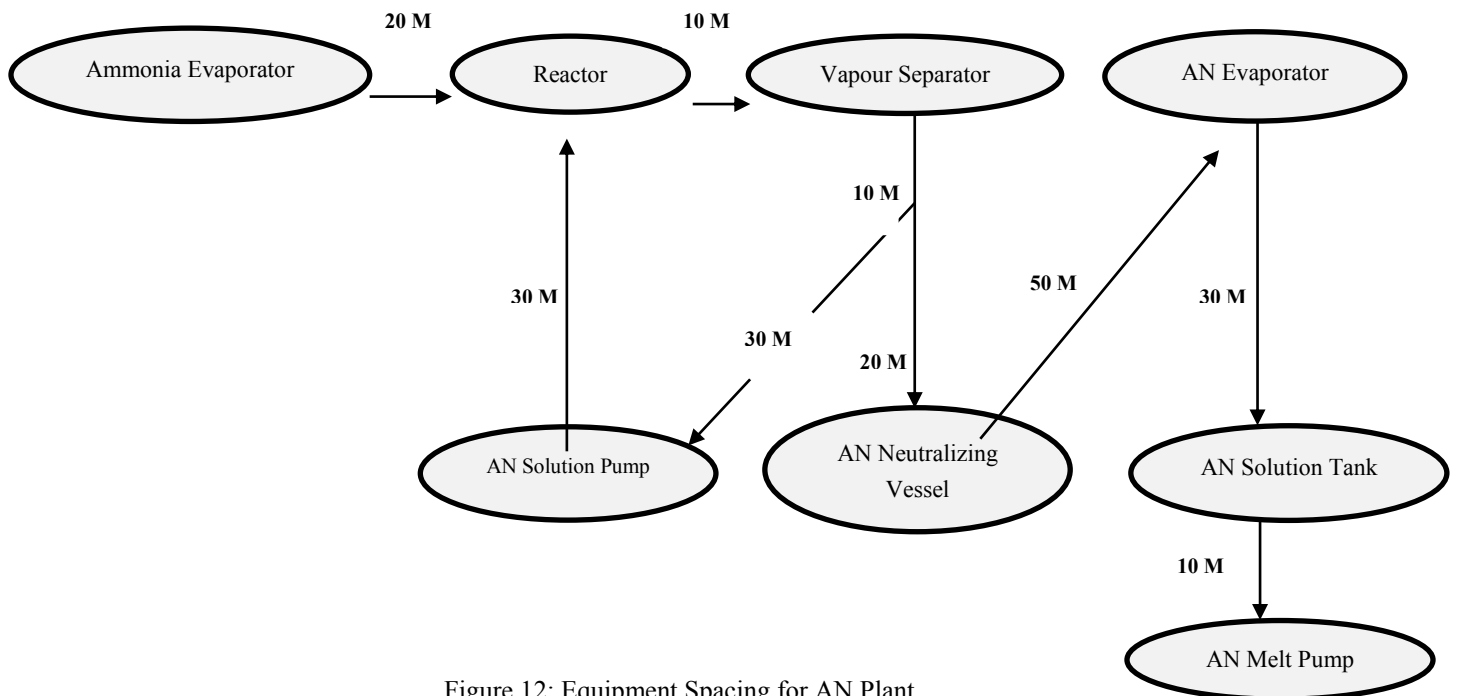

Figure 12: Equipment Spacing for AN Plant.

7. PLANT LAYOUT

This section will cover the general plant layout, including possible locations for expansion and the arrangement of the administrative and equipment spaces. To arrange the plant in the orientation depicted in Figure 13, it is crucial to be aware of the direction and strength of the wind. It would therefore make sense to examine Al Ain Al Sokhna's wind atlas, also known as the "wind rose." Despite the lack of a Windrose for Ain Sokhna, the wind direction at Ain Sokhna can be estimated using the wind rose of the adjacent Gulf of Suez [17].
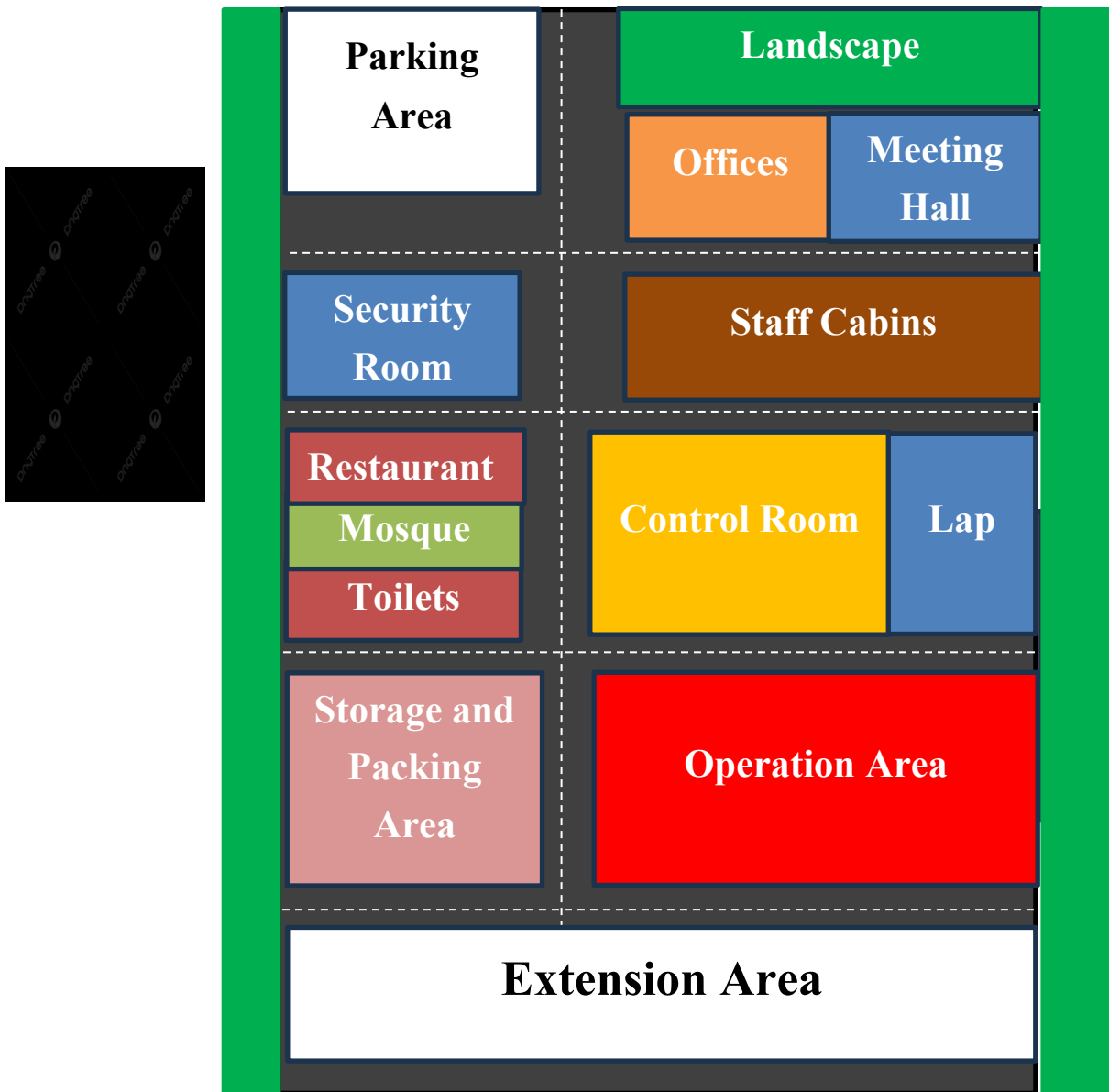
Figure 13: Layout for AN Plant.

8. SITE LOCATION

The following sites have been taken into consideration:
- Ain sukhana, Suez.
- Damietta

Table 42: Site Location for AN plant.

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No.	Location Factor	Weight	Suez	Damietta
1	Supply of Material	100	95	60
2	Market	60	40	20
3	Transportation Facilities	80	80	40
4	Avalibality of Labour	70	60	70
5	Avalibality of Utilities	50	40	15
6	Avaliabality of suitable land	50	40	30
7	Environament Impact	50	35	30
8	Climate	50	40	30
9	Political and Strategic Considration	50	30	20
10	Location	50	40	40
	Total	640	500	355

Plant depend on Ammonia so it should best be located close to the Ammonia source to decrease transportation economics. As shown in table 42 the best location of this plant is Suez.

9. COST ESTIMATION

Cost estimation is a specialized subject and a profession in itself. However, the design engineer must be able to make quick and approximate cost estimates to choose between alternative designs and evaluate the project. In this study, the capital cost of starting the factory was determined, including the price of various pieces of equipment, the cost of land, etc as shown in Table 43, Table 44, Table 45 and Table 46. The annual operating cost for producing ammonia nitrate was also calculated in Table 47, taking into account that the completion rate in the factory is 95%, as the factory is operated for 347 days per year [18].

Table 43: Fixed and variable cost.

PCE	2288464.405 $
PPC	7780778.977 $
Fixed Capital Cost	11282129.52 $
Total Investment	12410342.47 $

Table 44: Sub section A.

Raw Materials	45146.08 $
Miscellaneous	112821.295 $
Utilities	549648 $
Shipping and Packaging	not applicable
Sub Section A	707615.375 $

Table 45: Sub section B.

Maintenance	1128212.95 $

Operating labor	647600 $
Laboratory costs	135996 $
Supervision	129520 $
Plant Overhead	323800 $
Capital charge	1128212.95 $
Insurance	112821.29 $
Local taxes	225642.59 $
Royalties	112821.2952 $
Sub Section B	3944627.075 $
Direct Costs (A+B)	4652242.45 $

Table 46: Sub section C.

Sales expense	1209583.037 $
General overheads	not applicable
Research and Development	not applicable
Sub Section C	1209583.037 $

Table 47: Production cost.

Annual Production costs (A+B+C)	$ 5861825.487 /year
Production Cost	$ 6.42 /kg

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