

Practical Experience in the Main Fertilizers Containing Nitrogen

Recirculation and Evaporation Stages

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Introduction

In March 2004, Engineer Reda Soliman Khalil has published the first edition of a very interesting and elaborative book describing the Practical Experience in the Main Fertilizers Containing Nitrogen.

In this book, which is unique in the industry, Engineer Khalil's focuses on three main fertilizer types: Urea, Ammonium Nitrate and Ammonium Phosphate, in addition to Nitric Acid, which is highly involved in the manufacturing of other various nitrogen-based types of fertilizers.

This book aims at combining the theoretical and practical experience in the main popular fertilizers produced mainly from ammonia, which is the basic access to all the nitrogenous fertilizers that involve nitrogen as a manufacturing component.

Currently Engineer Khalil is Managing Director, Fertilizers, ORASCOM CONSTRUCTION INDUSTRIES and Board Member, SORFERT ALGERIA.

We are proud that Engineer Khalil is one of our Experts (refer to: <http://www.ureaknowhow.com/ukh2/urea-network.html>)

This part discusses the Recirculation and Evaporation stages in a Stamicarbon CO₂ stripping urea plant.

Recirculation stage Stamicarbon process

In the circulation stages, the major part of the unconverted ammonia and carbon dioxide is removed from the urea solution.

The urea solution from the H.P. stripper is transferred to the rectifying column, while it loses the unconverted ammonia and carbon dioxide by means of gases rises from the re-circulation heater at the bottom of the rectifying column, where urea solution coming from the upper part of the rectifying is heated in the tube side of the re-circulation heater by the means of low pressure steam in the shell side.

The solution is concentrated to about 73 - 75% and separated in the separator implemented with rectifying column is sent to the flash tank through the level control valve, while the gases rise to heat

up the coming urea solution carrying more gases and are sent to the low pressure carbamate condenser.

Rectifying Column

The rectifying column is a packed column, provided at the bottom by the separator and heater recycle. The urea - carbamate leaving the H.P. stripper is expanded via level control valve from about 140 bar to 4.1 bar causing decomposition of carbamates to ammonia and carbon dioxide.

The required heat for this decomposition is supplied from the sensible and latent heat of this solution, where its temperature is dropped from 173 to 119 °C. The mixture is then entered to the upper part of the rectifying column via tangential inlet. The solution flows down through a packed bed of the ball rings. The separated gases leave the top of the rectifying column for the L.P. carbamate condenser. The solution, which flows down over the packed bed is led to the re-circulation heater, where the temperature is raised to 135 °C by means of the L.P. steam.

The result of heating in the heater re-circulation is other carbamate decomposition. The temperature of the solution heated in the re-circulation heater is controlled by the temperature control valve, which controls the steam to the heater.

The solution heated in the re-circulation heater is discharged to the separator located between the re-circulation heater and the rectifying column. In the separator the gas and solution are separated.

The gases rise up to the rectifying column bed, which helps in the heating of the descending solution and the gases are cooled causing condensing of some water vapour.

Flash Tank

The solution from the separator in the rectifying column flows to the flash tank through the level control valve, where the pressure is further dropped from 4.1 to 1.1 bar, causing the evaporation of some water and ammonia and decreasing the solution temperature from 135 to 106 °C.

The pressure in the flash tank is controlled at an atmospheric pressure by means of pressure control valve.

The solution from the flash tank is concentrated to about 83-85% weight in the pre-evaporator and then sent to the urea solution storage tank.

In case of using prilling mechanism for the final product, the urea solution from the flash tank is sent directly to the urea solution storage tank, where it is concentrated after that via two stages evaporation or concentration unit to reach a concentration of about 99.8%, which means the urea melt phase.

The vapours from the flash tank are discharged to the flash tank condenser.

Low Pressure Carbamate Condenser

The gas mixture leaving the top of the rectifying column, which is a result from the expansion of the solution from the stripper and the decomposition of the carbamate in the re-circulation heater, with a temperature of 119 °C is introduced into the bottom of the L.P. carbamate condenser together with the solution from the reflux condenser (condensed gas from desorption column I).

Heat of the condensation in the L.P. carbamate condenser is removed by the closed circuit circulating conditioned cooling water via circulation water cooler, and kept filled under the pressure by the expansion drum located above the circulating cooling line at the highest point in the system by 2.5 m.

The carbamate formed as a result of condensation of ammonia and carbon dioxide at 74 °C overflows to the level tank for the L.P. carbamate condenser and recycled to the H.P. scrubber through the H.P. carbamate pump.

Controlling the Concentration of Carbamate to the H.P. Scrubber

Controlling the concentration of the carbamate solution at about 31 % weight is achieved by two methods:

- a) Introducing lean carbamate solution from the reflux condenser, where the gases from the first desorber column are condensed.
- b) Addition of the process condensate from the ammonia water tank by means of the same pump feed to the desorber and controlling the flow by the flow control valve.

How to avoid Crystallization?

The crystallization temperature depends on two factors:

- a) The concentration of the solution
- b) The ammonia / carbon dioxide ratio.

As explained before, how concentration can be controlled, also the ammonia / carbon dioxide can be controlled by supplying ammonia to the L.P. carbamate condenser.

Ammonia is taken from the intermediate tank and to a limit that keeps the ammonia / carbon dioxide ratio above 2 and this can be adjusted via the flow indicator with hand valve.

Operating Parameters in the Circulation Stage

The pressure in the re-circulation stage is 3.2 barg and measured at the level tank and controlled by the control valve PIC, and regulate circulating cooling water temperature.

Circulating cooling water temperature is controlled by controlling the cooling water supply.

The pressure can also be controlled by opening the temperature control valve, which controls the amount of the vent gas from the L.P. carbamate condenser. This control way can avoid the strong acting of the pressure control valve.

The inlet cooling water temperature at the condenser normally should be around 55 °C. At 54 °C in the lower part, the temperature control valve can be opened to the vent gas outlet level tank, preventing the temperature of the circulating cooling water temperature from decreasing too much.

Too low cooling water temperature can cause scaling on the tubes of the L.P. carbamate condenser. L.P. carbamate condenser and level tank can be drained to the ammonia water tank.

Flash Tank Condenser

The vapour coming from the flash tank after the rectifying column, from the level tank of the low pressure carbamate condenser, and from the level tank of the reflux condenser is introduced at the upper part of the shell side of the flash tank condenser with the process condensate from the same

source to the desorber to increase the efficiency of the absorption and condensation and to adjust the concentration of the formed carbamate solution.

The condensable gases such as water vapour and ammonia will be condensed, while the carbon dioxide will be absorbed by the ammonia water solution to form lean carbamate solution and collected in the level tank of the flash tank condenser.

The non-condensable gases, containing ammonia and carbon dioxide with traces of other inerts will be vented from both the flash tank condenser and its level tank to the atmospheric absorber by means of the pressure control valve.

The flash tank condenser operates under about 1.1 barg, and is considered a vertical shell and tube heat exchanger.

Note: Normally steam is used to prevent the deposition up – and - down the control valve where there are possibilities to entrainment of the carbamate solution with gases.

Pre-Evaporator

In case of the HFT granulation process, it needs a concentration of 96.5%.

The urea solution from the rectifying column having a temperature of 135 °C and a pressure of 4.1 bar is introduced to the flash tank. The pressure in the flash tank is maintained at a 1.1 bar, as a result of the pressure drop between the rectifying column and the flash tank. Water, ammonia, and some carbon dioxide are evaporated decreasing the solution temperature from 135 to 107 °C.

The solution from the flash tank in addition to the weak solution of 45% concentration from the dissolution tank of the granulation plant is introduced to the pre-evaporator.

In the pre-evaporator, the urea concentration is increased to about 80-83% at a temperature of about 100 °C and a pressure of 0.5 bar.

The pre-evaporator is provided by a separator, where the liquid and vapour phases are separated. Vapour is discharged to the evaporator condenser that operates by motive steam ejector, whereas the urea solution overflows to the urea solution (storage) tank.

The low-pressure steam is used as a heating source in the pre-evaporator.

The pressure in the pre-evaporator can be controlled by the hand control valve, which can be also used to control the solution temperature outlet the pre-evaporator.

In addition, the solution temperature is controlled by a temperature control valve, which has a cascade with the steam pressure control valve to the pre-evaporator.

a) How to minimize Biuret Formation in this Stage

The biuret content can be minimized by the following recommendations:

- Lowering the temperature as possible in the evaporation section up to the degree, which prevents crystallization.
- Short residence time in the urea solution tank.
- Feeding the urea solution to the final evaporator from the smallest compartment.
- Ensuring some proper amount of ammonia content in the solution to avoid low partial pressure of ammonia, which lead to the formation of biuret.
- Avoiding the storage of the solution at a high temperature (the optimum storage temperature is about 95 °C)

N.B.: Urea solution tank is divided into two compartments; a big compartment and a small one. The bigger compartment acts as a spare storage solution tank in case of any overflow from the small compartment and in case of any short shutdown of back end of the plant.

b) How to Protect the Solution Tank from Over & Under Pressure

The storage solution tank can be protected from over and under pressure by:

- A water seal on the tank roof, filled with a steam condensate.
- The tank overflow drips into a seal pot.
- Venting the tank via vent connected with the vent stack.

Final Evaporator

The urea solution is pumped to the final evaporator via pumps and flow control valve. The concentration of urea is increased from 80 - 83% to about 96% at a temperature of 130 - 135 °C and a pressure of 0.3 bar.

The evaporator is equipped with a separator, where the liquid and vapour phase are separated. The vapour is withdrawn by the action of the ejector to the condenser, while the liquid overflows to pumping towards granulator.

The L.P. steam is used as a source of heat to the evaporator. The temperature of the solution is controlled by the temperature control cascade with the steam pressure control.

Also the temperature of the solution can be controlled by controlling the heat surface by varying the level of steam condensate in the shell of the evaporator.

The separator is provided with vanes mounted on the ring at the top part. When the vapours evaporate from the urea solution, leaving the separator and passing the vanes, droplets of urea that are dragged along with the vapour will be caught and fall back into the separator. These vanes should be continuously flushed by steam through the perforated ring.

In some cases, flushing is handled one time per shift using steam condensate, but it is preferred to use steam and continuous flushing to avoid the accumulation of urea droplets that might block the top part, and also to minimize the biuret formation.

The vapours are discharged (withdrawn) from the separator to the condenser by the action of steam driven ejector. The heat of condensation is removed by cooling water on the tube side of the condenser.

The condensed process condensate is flowing to the ammonia water tank at 45 °C temperature.

The non - condensed gases are withdrawn from the condenser by the ejector and sent with steam used by the ejector to the atmospheric absorber.

The pressure in the evaporator separator is controlled by automatic pressure control, admitting air into the condenser by actuating the control valve at the air inlet to the common vapour line before the condenser.