Zero waste urea production

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In most industrial production processes and thus also in fertilizer production processes in general there are side products which cannot be further processed. Examples of such side streams are products that are out of specification, intermediates and by-products, all of which normally end up as waste. These waste streams are either dumped in landfills, incinerated, or otherwise wasted, putting a burden on the environment and resulting in a negative economic impact for fertilizer producers.

Stamicarbon's sustainable solution

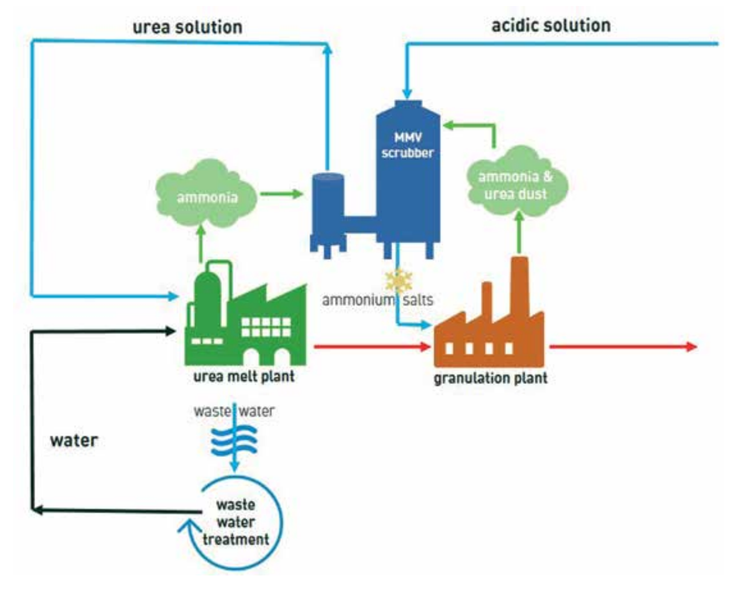
Over the past 70 years, Maire Tecnimont Group's innovation and license company, Stamicarbon, has been developing its own proprietary urea technology. The set-up it has today guarantees that nearly all emissions from the individual process steps can be converted to valuable feedstocks. They are all returned to the production process to avoid waste streams and/or by-products and therefore this urea technology can be considered a zero waste production technology. In addition, the technology has the capability to upgrade possible return streams into premium end-products.

The urea production technology layout (figure 1) basically consists of the following essential elements:

- Urea melt plant,
- Urea granulation (or prilling) plant,
- MicroMist Venturi scrubber, which removes both the gaseous (ammonia) emissions from the urea melt plant, as well as the particulate matter emissions (urea dust) from the air circulated in the granulation plant,
- Waste water treatment section, which cleans the effluent from the urea melt plant.

The target of the different sections is to reduce the emissions to air and water to such low levels, that the required environmental emission levels are met. In specific cases, even

Figure 1. General layout of the Stamicarbon urea plant



the remaining small emissions can be further treated with incineration or flaring to zero emission levels, such that we even can speak of zero emission production.

Obviously, this is at the cost of increased NO_x and CO_2 emissions. In the framework of this article, the specific details of such a layout will not be further elaborated, because this has already been addressed in a separate article by Stamicarbon.

The emissions of the urea melt and granulation plant are converted to feedstocks which can be reprocessed in the urea melt or granulation plant, in order to obtain zero waste production. Each individual unit below is needed to obtain a zero-waste production layout.

MicroMist Venturi scrubber

The MicroMist Venturi (MMV) scrubber is a multi-stage process for the effective and efficient scrubbing of urea particulate matter and ammonia gaseous residues from the urea melt and the granulation plant to meet the more stringent particulate matter emission regulations. During the granulation process, submicron dust is generated which is mainly responsible for the higher emission values. While older technology scrubbers easily scrub larger particles, the presence of a high degree of submicron dust requires a new capture approach, and to efficiently remove ammonia, an acid solution needs to be injected. This newly introduced scrubber technology is successfully implemented and proven in other industrial applications, but is completely new for the urea industry. The MMV scrubber contains five stages that progressively treat and clean the off-gas (figure 2). With this technology, emissions of less than 10 mg/Nm³ for dust and 20 mg/Nm³ for ammonia can be achieved.

> *The target is to reduce emissions to air and water*

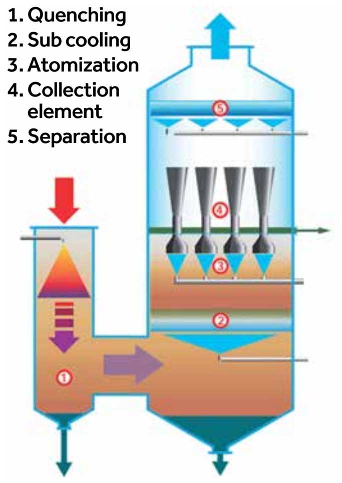
At the first stage, the exhaust gas is cooled down, saturated and most of the coarse particulate urea dust is collected from the gas stream. At this point in the process the concentrated urea solution is purged and available for further (re)processing. The concentrated urea solution is typically between 35 and 45 wt-% urea, and can be fed to the urea melt plant. Downstream of the first quench zone, a secondary quench is used. In this second quench, a dilute solution of urea is used to further cool and humidify the gas flow. This process is a very important step to assure that remaining submicron particulate is exposed to saturated gas, where particles can substantially grow in size through condensation. Inside the scrubber vessel several Dual-Orifice Conditioning (DOI) trays can optionally be installed to further condition the gas stream. Multiple parallel venturi tubes are installed vertically on a diaphragm in the vessel.

The diaphragm forces the gas flow to accelerate through the tubes (figure 3). Each venturi tube includes a converging conical section (the inlet) where the gas is accelerated to throat velocity, a cylindrical throat, and the diffuser outlets of the MMV tubes are aerodynamically designed to reduce the overall pressure drop by slowing down the gas and recovering the energy. In the tubes, gases interact with the particulates and droplets twice (acceleration and deceleration).

Downstream the MMV stage, the ammonia acidic scrubbing takes place. The DOI tray is flooded from above with acidified water and the acid flow rate is controlled by a pH measurement. Typically, sulphuric acid or nitric acid are used to neutralize ammonia, forming an ammonium salt. Depending on the type of acid used, ammonium sulphate or ammonium nitrate salts are formed. They can be fed as a feedstock to the granulation plant in case of ammonium sulphate to produce urea with traces of sulphur. Alternatively, they can be used in a secondary process such as a UAN plant in case of ammonium nitrate, or being supplied to other processes, depending on the specific process layout chosen. By further addition of ammonium sulphate in the granulation plant, urea ammonium sulphate (UAS) compounds are made, satisfying the growing need for sulphur, which has meanwhile become the fourth macro nutrient.

Remaining suspended water droplets are removed from the gas stream in the mist eliminator before the gases leave the scrubber. Fresh (clean) water is continuously sprayed on the mist eliminator to catch and wash away dirty particles. For prilling plants a similar scrubber is available.

Figure 2. MMV Scrubber stages layout



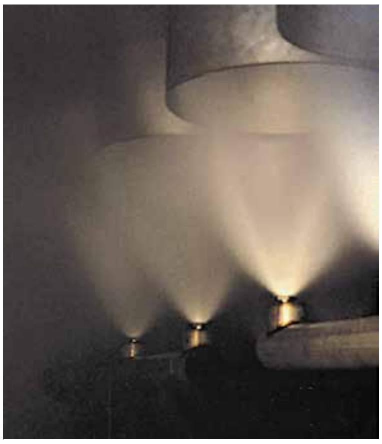
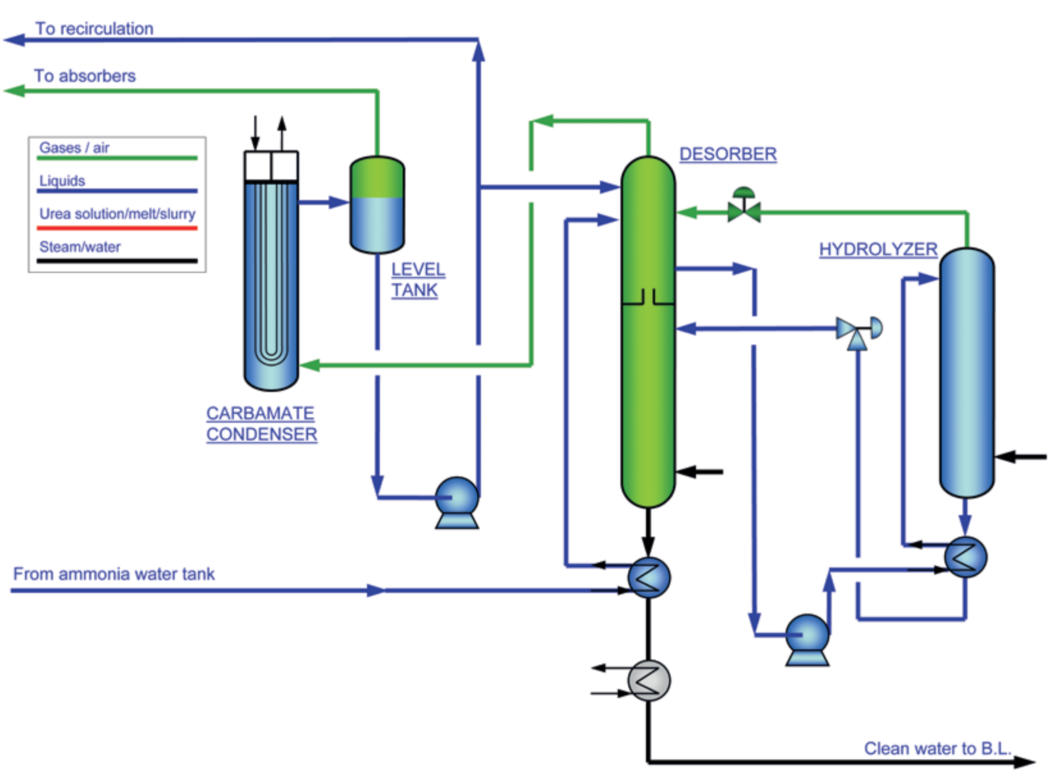


Figure 3. MicroMist Venturi

Figure 4. Stamicarbon's waste water treatment section



An optional Wet ElectroStatic Precipitator (WESP) can be integrated on top of the MMV scrubber to further reduce overall emissions.

Waste water treatment

In the waste water treatment section liquid effluents from the granulation and urea melt plants are treated (figure 4). The process condensate coming from the evaporation section, together with other process effluents such as sealing water from stuffing boxes, contain ammonia and urea. All of the process condensates are collected in the ammonia water tank. From this tank, the waste water is fed to the top part of the desorber. In the top part of the desorber, the bulk of the ammonia and carbon dioxide are stripped off from the water phase by using the off-gas from the bottom part of the desorber as a stripping agent. The descending effluent still contains urea and some ammonia. To remove the urea, this effluent is then fed to the hydrolyser, which is a liquid-filled column. In the hydrolyser the urea, at elevated pressure and temperature, is dissociated into ammonia and carbon dioxide by the application of heat (steam) and retention time. The process condensate feed is kept in counter-current contact with the steam in order to obtain extremely low urea content in the hydrolyzer effluent. The remaining ammonia and carbon dioxide in the effluent of the hydrolyzer are stripped off with steam at a reduced pressure in the bottom part of the desorber. The off-gases leaving the top part of the desorber are recycled to the synthesis section after being condensed in the reflux condenser.

The purity of the remaining water satisfies requirements for usage as boiler feed water or cooling water make-up, which means that Stamicarbon urea plants do not produce any waste-water stream. In addition, the water is reused in the granulation plant, or can be used for the production of DEF (Diesel Exhaust Fluid), depending on the plant configuration.

Due to the optimal layout of process components, not only the required emission levels are achieved, but effectively also a zero-waste urea production process has been developed. This satisfies not only legislative bodies in providing an optimal solution towards environmental emissions, but also meets both economic and environmental challenges. Prevention of waste generation leads to high efficiency, as all feedstock is transformed into final product, and avoids the burden of waste disposal. This has both a cost component, but also leads to pressure on the environment. Stamicarbon's urea technology leads to a truly sustainable, zero waste production process, meeting the challenges of today and tomorrow.

Note: MicroMist™ is a registered trademark ■