Latest Application of Casale Technologies to Urea Plants

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UreaCasale

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Abstract

Recently Casale has successfully carried out major projects in the field of urea applying its well-known technologies. As described in several publications, Casale disposes of various innovative technologies for the revamping of urea plants, to obtain large capacity increases, and for the construction of new ones.

This paper gives an overview of some projects recently completed, which involved the application of the above mentioned technologies.

Foreword

Significant and recently accomplished examples of urea revamping projects aimed at fulfilling large capacity increase are:

- The Toyo Total Recycle Urea plant revamping of Mesaieed (Qatar) in connection with the installation of the new Eurotecnica melamine plant (start up Jun.-’09).
- The Ammonia Stripping Urea plant revamping of Novomoskovsk (Russia, start up Nov.-‘09).

Each of the cases listed above represents a very important example of innovative technology for large scale revamping projects applied to urea plants originally designed with the most wide spread technologies in the world.

In the paper, together to the main results obtained, an overview of the most important Casale technologies applied to the urea plant revamping is also given.

Casale Technologies and their application to urea plant revamping and design

General considerations on urea plant revamping

Since the start of its activity, Urea Casale has developed several technologies for the revamping of urea plants, aimed at increasing the efficiency of the various sections or of the equipment.

The general revamping philosophy of Casale has, in fact, always been based on upgrading the plant with new technologies, on maximizing the efficiency the most important plant sections and on minimising modification to the existing plant

A urea plant revamp, can touch different areas and is, generally, aimed to improve the performance of an existing plant.
Every urea plant revamping project can be different from previous ones. The plant owner can have different goals to reach and the plant, even if designed with the same technology, may have different bottlenecks.

The starting point for each project is the identifications of client's goals and of the actual plant bottlenecks. A plant survey is organised in order to collect actual plant data and plant information. A base case material and energy balance is developed reflecting actual operating condition.

After this first phase, Casale proposes a tailor-made technical solution that is considered to reach the required goals with the best return. Casale generally proposes the best combination of its technologies and of third parties technologies available to it.

For every revamping project, Urea Casale proposes one or a combination of these technologies in order to offer the most efficient revamping solution to the client.

One can identify the following main typologies of urea plant revamping projects on which Casale has worked and developed various technologies:

- energy saving
- capacity increase
- pollution control
- integration between melamine and urea plants

Often revamping projects may involve combinations of the above typologies.

In the next sections, the Casale approach for the above typologies and the related Casale technologies will be described.

Energy saving

The projects aiming at reducing the energy consumption are generally characterized by the need of improving the efficiency of the plant with low investments. The returns generated by a project aiming at just reducing the energy consumption do not, in fact, justify very large investments.

One can improve the efficiency of the various components or sections of the plant or the energy integration.
In order to improve the efficiency of one of the most important component of a urea plant, Casale has developed some times ago an innovative design for the urea reactor trays, which is described here below, and achieve an improvement of the plant efficiency with low investment.

Whenever possible, Casale also proposes to improve the energy integration within the plant by improving the energy recovery.

Casale-Dente High Efficiency Trays

The development of this technology was the first example, in Casale activity in the urea field, of how the investigation and analysis of complex phenomena, and the ability to picture it through the combination of process design and fluid dynamics tools, could lead to the development of most advanced technologies.

In collaboration with Professor Dente, Urea Casale was able, through an accurate modeling, to identify all the parameters that are influencing the formation of urea inside a urea reactor. Through the modeling it became clear that a good transfer of mass and heat within the phases of the heterogeneous reacting system of urea is of essence to reach a high conversion in the reactor. With the models, it was also possible to identify that the existing designs of internals (trays) used in urea reactors could be improved.

The Casale-Dente High Efficiency Trays design improves the tray geometry realizing a higher mixing with a much better mixing between the liquid and vapor phases.

The new trays are, in fact, designed so that:

- Separate and distributed paths through the tray are provided. They guarantee a steady state flow of the two phases and better approach an even uniform flow of the two phases throughout the whole reactor.

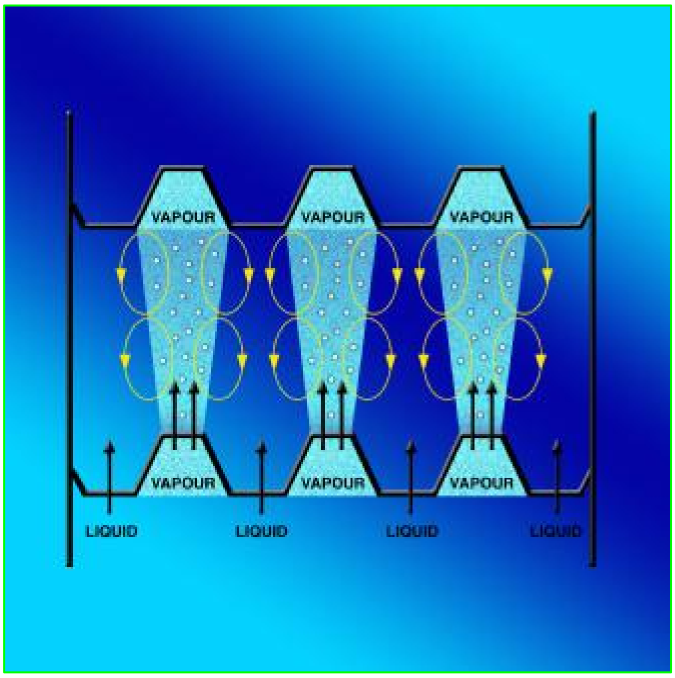


Fig. 1 - Casale-Dente High Efficiency trays

- These separated paths through the tray are chosen so that a very high mixing efficiency between vapor and liquid is obtained. Consequently a very high mass and heat transport within the liquid phase is realized.
- With an appropriate design, the diameter of the generated vapor bubbles is smaller than in any previous design.
- By consequence, the interfacial surface, for mass and heat transfer, is increased.
- A much higher mixing within the liquid phase is also obtained.

The trays are made up by several inverted U beams with large perforations for liquid passage on the bottom wings, and small perforations for gas passage on the sloping and top sections.
With this unique design, very small bubbles are generated, and by consequence, very high specific surface for the mass and heat transfer is obtained. This advantage is combined with a very high efficiency in the mixing between vapors and liquid.

The Casale-Dente High Efficiency Trays are used for any project aiming at reducing the steam consumption and/or at increasing the plant capacity.

So far the Casale-Dente High Efficiency Trays are operating in more than 50 urea plants.

Pollution abatement

The emissions of a urea plant to the environment are either the excess process condensate, which has to be discharged to keep the water balance, or the vent where the inerts are discharged to avoid accumulation. Both these emissions are contaminated with compounds involved in the urea synthesis and have to be purified to the most possible extent in order to satisfy environmental regulations, which are becoming more and more severe.

The process condensate stream generally contains NH_3, CO_2, and Urea. The majority of plants treat the condensate to recover CO_2 and most of the NH_3 in order to minimise raw material losses. Many plants, however, do not have the capability of either completely eliminating NH_3 and Urea or reducing their content below the accepted values.

In order to reduce the liquid emissions, Casale disposes of a proprietary hydrolyzer of increased efficiency, called High Efficiency Hydrolyzer (HEH), which is described here below and allows to completely eliminating Ur from the process condensate.
Utilizing appropriate more efficient scrubbing designs, which are proposed according to its know-how and experience, Casale can reduce the emissions from the vents down to very low values complying with the most stringent regulation.

Casale High Efficiency Hydrolyzer

In order to reduce the liquid emissions, Casale has developed a new hydrolyzer of increased efficiency, called High Efficiency Hydrolyzer (HEH), which allows to completely eliminating Ur from the process condensate.

The Casale High Efficiency Hydrolyzer (see Fig. 2) makes efficient use of the stripping action of steam to remove the NH_3 and CO_2 from the treated urea plant waste water condensate in order to maximize the hydrolysis of the urea content.
The efficiency is enhanced by the fact that the hydrolyzer is divided in two zones in order to keep the driving force for the NH_3 and CO_2 removal as high as possible. It is, in fact, very important to eliminate NH_3 and CO_2 from the liquid as much as possible as, since the NH_3 and CO_2 are products of the hydrolysis reaction, their presence tends to slow down the hydrolysis.
Both zones are provided with High Efficiency Casale Trays, which divide them in compartments. In each compartment the liquid is separated from vapors (containing NH_3 and CO_2), creating a multiplicity of streams of vapors, which are injected again into the liquid in form of column of small bubbles maximizing the mass and heat transfer. The two zones have the following characteristics:

- First Zone:

The first zone, fed by the waste condensate to be treated, is operating in "co-current" with injection of 22-24 bar steam in the bottom.
At the top of the first zone the vapors are finally removed from the liquid which is then treated in the second zone.

- Second Zone:

The second zone, fed by the liquid coming from the first zone, operates in "counter-current" with liquid going downward and vapor going upward. Fresh 22-24 bar steam is injected again in the bottom of this second zone. The driving force for the extraction of NH_3 and CO_2 is, in this way, increased, allowing to reduce urea content to less than 3 ppm.

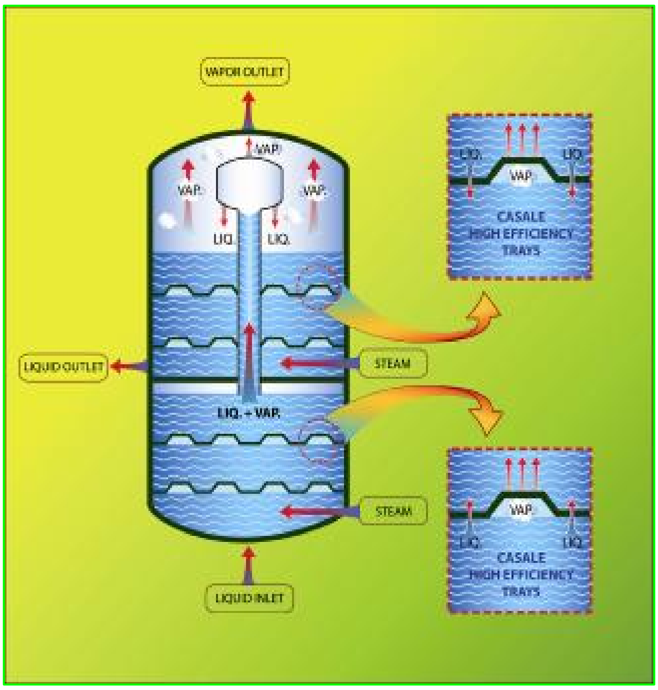


Fig. 2 - High Efficiency Hydrolyzer

The vapors are separated from the liquid at the top of the zone and exit the hydrolyzer together with the vapors coming from the first zone.

With the help of Casale High Efficiency Hydrolyzer, adding, if necessary, one or two stripping columns, it is possible to completely eliminate NH_3 and Urea from the process condensate reaching residual values lower than 3 ppm.
This value meets the requirements for boiler feed water; the treated condensate can, therefore, be used as boiler feed with economical advantages.

The Casale High Efficiency Hydrolyzer is used when it is necessary to reduce the emission of Urea and NH_3 through the process condensate, or to increase the capacity of existing hydrolyzer.
Existing hydrolyzers of certain types can be also conveniently revamped by changing the internals with new ones designed according to the High Efficiency Hydrolyzer technology.

Capacity increase

The way a capacity increase project is approached depends, of course, from the required increase. In general, in order to maximize the return of such kind of projects, it is essential to be able to increase the efficiency of the existing plant by upgrading the most important items or the entire process itself.

In case of a small to moderate capacity increase the investment should be kept as low as possible to guarantee a reasonable return, and the High Efficiency Trays is most appropriate technology to increase the efficiency of the plant with minimum investment. The installation of these trays is, in fact, minimizing the modifications required to the rest of the plant.

In case of a large, or very large, capacity increase, a more substantial increase in the plant efficiency is required. In this case Casale has developed various technologies, which are the HEC, the VRS and the Split Flow Loop™ / Full Condenser™, in order to approach the revamping for large capacity increase of the different type of urea plants. These technologies are described here below.

Thanks to its performances, the combination of the **Full Condenser**ä concept with the **Split Flow Loop**ä concept is a very powerful tool to debottleneck CO_2 stripping plants.

In combination with other Casale technologies such as the High Efficiency Trays, these technologies are conveniently applied, by transforming the existing plants to the new configurations, to increase the capacity of existing plants.

Particularly simple is the transformation of existing CO_2 stripping plants into the **Split Flow Loop**ä / **Full Condenser**ä configuration, which is obtained by:

- Additional internal parts in the HPCC to transform it to the **Full Condenser**ä configuration
- Some piping modification to re-route some lines according to the **Split Flow Loop**ä concept
- Addition of a new ejector

HEC (High Efficiency Combined) Process

The development of this process opened the way to very large capacity increases, 50% or more, of conventional total recycle plants.

This process, based on the combination of a very efficient "once-through" reactor (primary reactor) and a conventional total recycle one (secondary reactor), presents the unique

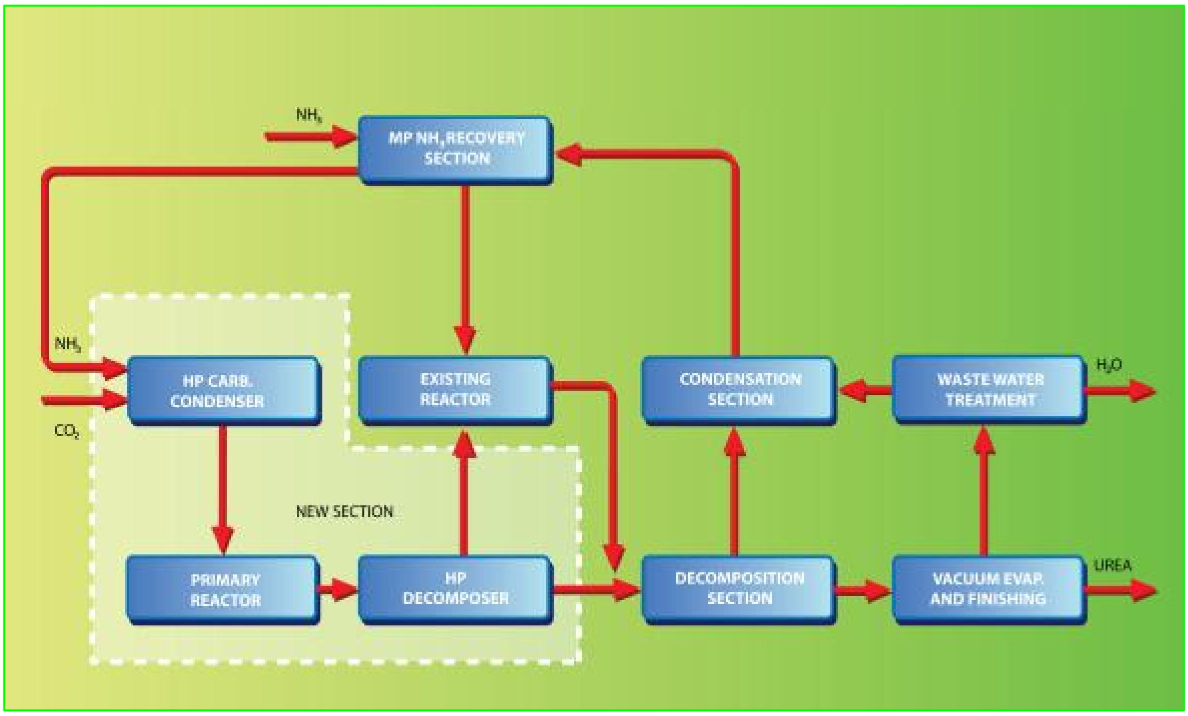


Fig. 3 - Conventional Total Recycle Plant revamped with the HEC Concept

feature of having a very high average CO_2 conversion, 70% to 75%, and by consequence a low energy consumption.

Most of the urea is produced, in absence of any water, in the primary reactor with a high yield, generally 75%. This reactor has a carbamate condenser upstream, for controlling the heat balance, and a HP decomposer downstream to recycle most of the un-reacted NH_3 and CO_2 directly into the secondary reactor, operating at lower pressure.

The urea solution from the HP decomposer joins the solution flowing out from the secondary reactor and together they feed a two stages recycling section with NH_3 recovery column.

The one described above is one of the two possible alternatives of HEC process. Another possible solution in fact is to install the HP decomposer on the liquid stream exiting the secondary reactor, while the solution coming from the primary reactor joins the one coming from the bottom of the HP decomposer, thus feeding the downstream section (see Fig. 9 for one practical application).

The capacity of conventional total recycle plants can be drastically increased applying the HEC process, and this with the addition of just few pieces of equipment.

In order to increase the capacity of conventional total recycle plants up to 50% or more, Casale proposes to install its HET in the existing reactor and to apply its HEC concept as follows:

- the existing reactor (fitted with Casale HET) is used as primary reactor;

- a section consisting of the secondary reactor, an HP carbamate condenser and an HP decomposer is added

The existing synthesis section will, therefore, be transformed in a HEC synthesis section and due to the much higher conversion obtained with the HEC synthesis section, the existing back-end of the plant can be re-utilized at higher capacity with only minor modification.

With this approach, the highest possible utilization of the existing equipment is reached, keeping the investment as low as possible.

For very large capacity increases a primary reactor is added while the existing reactor will be used as secondary reactor.

After revamping, the following consumption's can be obtained:

- raw materials almost steichiometric
- MP steam ab. 900 kg/MT

<u>Split Flow Loop™ and Full Condenser™ Concepts for CO_2 Stripping Plant Revamping, the latest development of Casale Technologies</u>

The development of these two technologies is the result of Casale constant research of improvements in urea plants and the latest example of how, also in urea field, the modelling is becoming more and more an essential tool for technical development.
These technologies are a powerful tool to increase the capacity of CO_2 stripping plants in a very efficient, and therefore economical, way

Vertical HP condensers have been used in the HP loop of urea plants designed according the CO_2 stripping technologies for many years.

In such plants (see Fig. 4), the effluent of the reactor is stripped in the HP stripper using CO_2, together with heat, as stripping media. In this way it is possible to recycle straight back to the reactor a good quantity of un-reacted NH_3 and CO_2.
All the vapors leaving the stripper need to be partially condensed before they are sent to the reactor in order to keep heat balance of the latter.

In order to obtain this partial condensation, all the vapors from the HP stripper are sent to HP Carbamate Condenser (HPCC), which is a co-current falling film condenser with the vapors entering from the top and condensing forming a film on internal surface of the tubes.
In the above described configuration, all those inerts introduced into the HP loop, through the CO_2 fed to the HP stripper, are reaching the reactor, through the HP stripper and the HPCC.

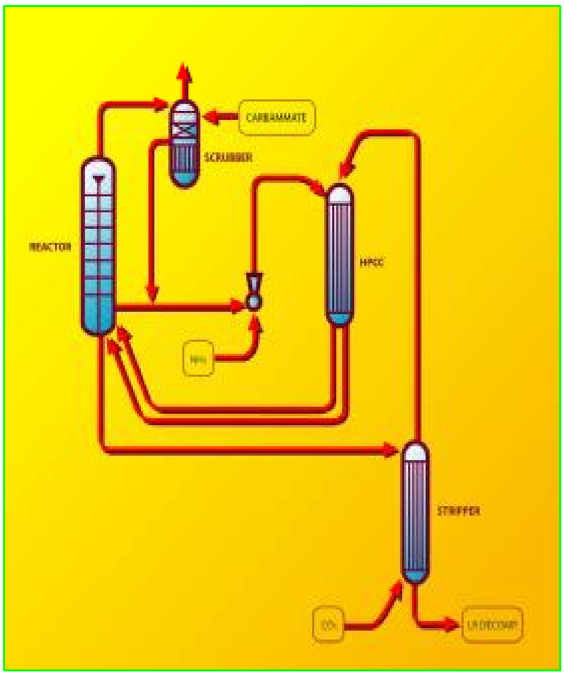


Fig. 4 - HP loop of CO_2 stripping plants

In order to find a way to improve the performance of the HPCC, Casale examined, from a theoretical point of view, the performance of different types of condensation.

It is well known that the condensation using a falling film configuration does not give the best condensation efficiency, and that the condensation efficiency could be improved if a bubble flow configuration (see Fig.5) is adopted, and this thanks to the fact that the bubbles give a much higher surface at disposal for the mass (and heat) transfer.

The falling film configuration is also sensitive to the distribution. An even distribution of liquid and vapor over all the tubes is not always easy to obtain and a non-optimal distribution is also negatively influencing the transfer efficiency.

Due to the above reasons, the tube side heat transfer coefficient can be, with bubble flow configuration, 4 to 5 times higher than with a falling film configuration.

Using a commercial package for the simulation of heat exchanger combined with its physical-chemical equilibrium models for urea, Casale made rigorous simulations of the two configurations mentioned above proving what said above, and also that an improvement of the tube side coefficient, by changing the flow regime inside the tubes to the bubble flow regime, would lead to an improvement in the overall coefficient.

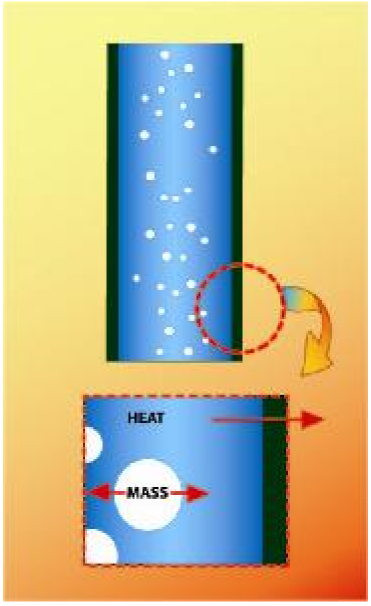


Fig. 5 - bubble flow configuration

Full Condenser™ Concept

In order to improve existing HPCC by changing the falling film configuration to the more efficient bubble flow configuration, Casale developed the Full Condenser™ concept according to which the condenser operates as a submerged condenser with a natural circulation replacing the standard falling film condensation regime.

According to the Full Condenser™ concept, an existing HPCC is modified so that a mixed two-phase flow rises up in most of the tubes.
A very small amount of tubes are left without vapor phase, and in those tubes liquid flows downward, thanks to the density gradient with the other tubes. This produces an internal natural circulation.
Consequently, the new internal flow regime is a bubble flow inside a continuous liquid. In this way, the interfacial area between two phases (liquid and gas) is significantly increased, so that the transfer performance of the exchanger is highly improved.

Moreover, the HPCC will be even better protected from corrosion in the new configuration, as all tubes surfaces will be better wetted.

The new flow patter of the HPCC is shown in the sketch of Fig. 6, and can be summarized as follows:

§ Vapors coming from HP stripper are fed through one of the bottom nozzle and distributed inside the continuous liquid phase by a distributor on the bottom of the HPCC.

§ The two-phase flow, thanks to its lower density, flows upward and along the tubes the vapors condense.

§ A two-phase flow exits the tubes from the top tube sheet and the inerts separates from the condensed liquid and exit the condenser from the top nozzle.

§ Fresh liquid (ammonia and carbamate mixture) enters the exchanger through the second nozzle in the bottom and is distributed in all tubes.

§ A top weir defines the liquid level in the top part of the condenser, the overflowing liquid exits the condenser through a new nozzle.

The optimal circulation ratio is determined by Casale in order to achieve optimal condition for the heat transfer in the two-phase upward tubes.

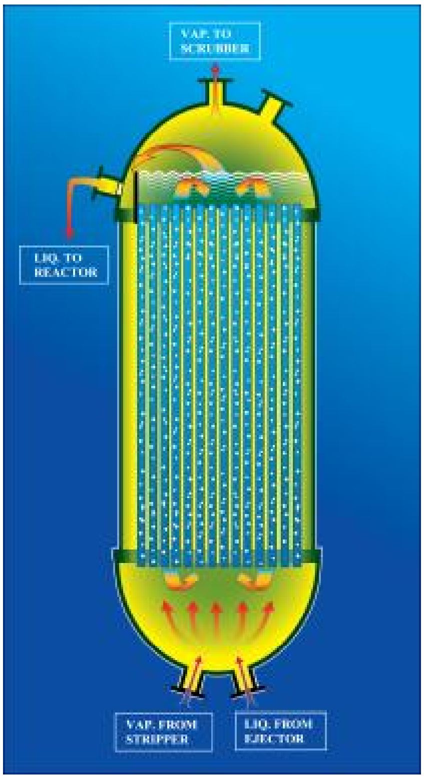


Fig. 6 - Full Condenser ä Configuration

<u>Split Flow Loop™ Concept</u>

Once transformed to the Full Condenser™ configuration, the HPCC can easily operate as a total condenser with only inerts and a small amount of vapors leaving the condenser uncondensed. This opens the way to a further improvement in the HP loop.

In order and to take most advantage from the Full Condenser™ configuration, and obtain also an increase in the efficiency of the loop, and in particular of the reactor, Casale has, therefore, studied a new configuration of the HP loop, called the Split Flow Loop™.

In this new configuration, the HPCC is operating as a total condenser and only the amount of vapors that actually has to be condensed in this equipment will go to the condenser. This is about 2/3 of the total vapor coming from the stripper.

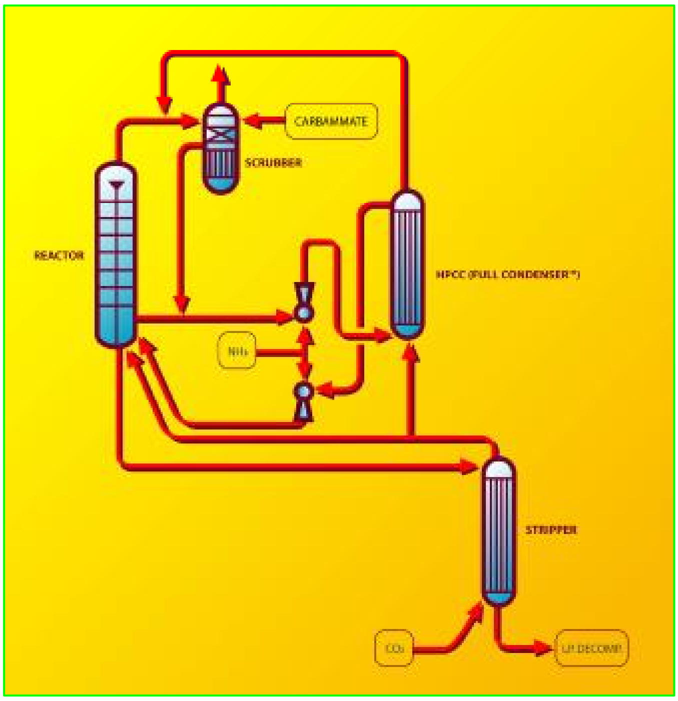


Fig. 7 - Split Flow Loop ä Configuration

The rest of the vapors, which in the standard configuration would leave the HPCC un-condensed, bypasses the condenser and goes directly to the reactor.

Total condensation in the condenser is not possible because of the presence of inerts, so that a small amount of not condensed vapors leaves from the top of the condenser and is sent directly to the scrubber together with the inerts.

In this way, about 2/3 of the total amount of the inerts present in the CO_2 are not sent to the reactor, and consequently the urea conversion increases.

Operating full of liquid, the Full Condenser™ is also, contrary to a falling film HPCC, contributing to the formation of urea as the operating conditions and the hold-up are such to start forming urea.

The liquid from the total condenser is sent to the reactor through a new ejector that enhances the driving force for the circulation. The new ejector is driven by part of the NH_3 feed that is bypassing the condenser.
A sketch of the Split Flow Loop™ configuration is enclosed in Fig.7.

Even though only 1/3 of the inerts are reaching the reactor and, therefore, also only 1/3 of the passivation oxygen is reaching the reactor, this amount is more than enough to guarantee the passivation of the reactor.
The amount of oxygen fed to the CO_2 is, in fact, calculated to guarantee proper passivation of the stripper that is the most critical equipment in terms of corrosion, and this amount is much more than the amount required for the passivation of the reactor.

With the Full Condenser™ concept, the overall Heat Transfer coefficient (OHTC) of vertical HPCC can be increased by at least 50%, and with the Split Flow Loop™ concept it is possible to improve the efficiency of the HP loop increasing the CO_2 conversion in the reactor by 2.5÷3 percentage points and increasing also the stripper efficiency. The Full Condenser™ concept also boosts the capacity of the existing reactor as urea is formed in the condenser.

Thanks to the obtainable increase of the HP loop efficiency, with the Full Condenser™ and Split Flow Loop™ concepts it is possible to increase the capacity of existing plants up to 50%.

Integration with melamine plant

A melamine plant, regardless of its design, is utilizing urea as raw material and, together with melamine, is producing also a by-product stream of NH_3 and CO_2 (off-gas), containing in some cases water.

Generally, a melamine plant is, therefore, erected next to an existing urea plant in order to have an easy supply of the raw material and to have the possibility to reprocess the off-gas back into urea, and generally the existing urea plant needs to be revamped in order to be integrated with the melamine plant in the most efficient way.

The main technical problems relevant to the integration of the melamine plant with an existing urea plant is connected with the fact that almost half of the urea fed to the melamine plant is dissociated into NH_3 and CO_2 that need to be transformed back to urea.

The impact of the integration of a melamine plant with an existing urea plant can be summarized as follows:

- Higher plant capacity is required to transform the NH_3 and CO_2 coming from the melamine plant back into urea, as the urea plant owner generally wants to maximize urea capacity for a given amount of feed stocks.
- Lower efficiency is reached in the synthesis loop due to the higher amount of water in this section coming from the additional carbamate formed with the NH_3 and CO_2 recycle from the melamine plant, with the consequent higher load to the main section of the plant.
- Higher load required to the recycling section of the plant for the condensation of the NH_3 and CO_2 recycle from the melamine plant.

Depending of the type of technology used for the melamine production, the magnitude of the impact to the urea plant can be different, but will always have the above type of drawback.

The solution of the technical problems of integrating a melamine plant with a urea plant in the most efficient way can be reduced at the end to find the best solution to the following two points:

- Find the way of minimizing the amount of additional water needed to generate the additional carbamate solution from the melamine off-gas.
- Find the best way to revamp the existing urea plant in order to efficiently increase its capacity and in order to compensate the negative effect of the integration on the plant efficiency.

To find the best solution to the second part of the problem, CASALE makes use of its own technologies to revamp any kind of urea plants improving to the maximum extent their efficiency, as described in the previous sections.

In additions, Casale has developed different proprietary designs for the unit that is interconnecting the melamine plant to the urea plant, which address the first of the above points providing an efficient way to condensate the off-gas from the melamine without overloading the existing condensation section, and, at the same time, reaching the goal of keeping to the minimum the amount of additional water needed to condensate and recycle the off-gas.

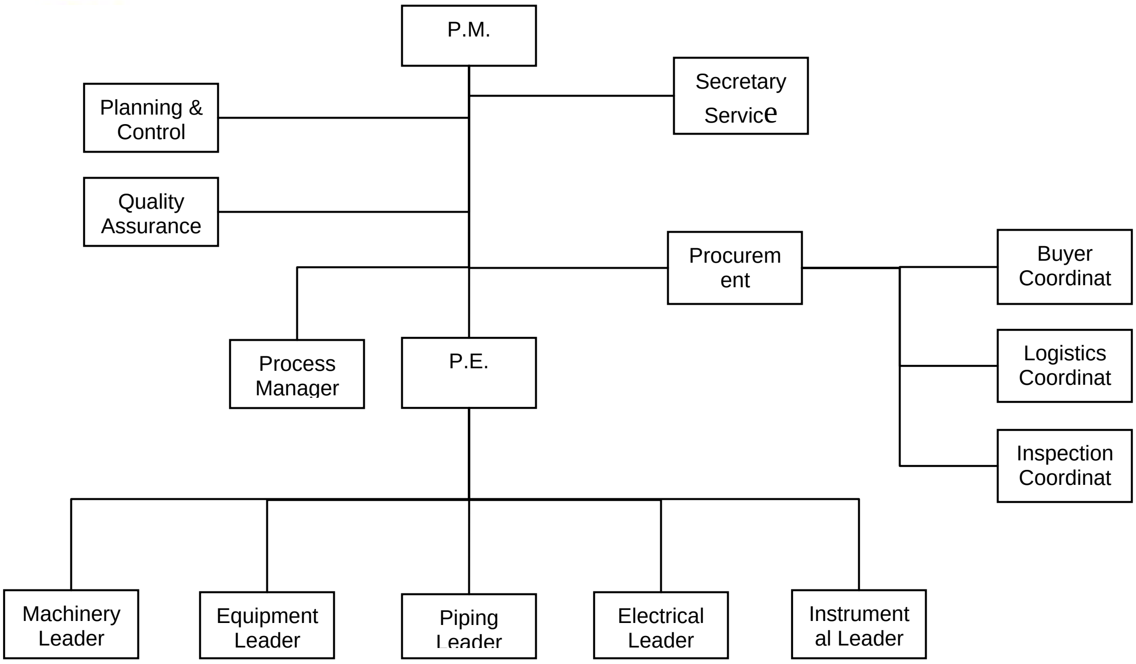
Case Study 1: QAFCO, Mesaieed (Qatar)

An Application of Casale HEC Technology for Toyo Total Recycle Urea Plant Revamping and Integration with Melamine Plant

In July 2006 Urea Casale (UCSA) and Qatar Fertilizer Company (QAFCO) signed a Contract for the revamping of the Total Recycle urea plant (Toyo technology) located in Mesaieed (Qatar).
The original capacity of QAFCO Urea plant n.1 was 1000 MT/D; the plant used to run, before the revamping, at the overall capacity of about 1300 MT/D.
The scope of the project was to integrate the existing urea plant with a 60,000 T/y melamine plant designed with Eurotecnica technology. The integration was aimed at increasing the urea synthesis capacity up to 1610 MTD (about +25%).

Regarding the organization and execution of the project, UCSA and QAFCO agreed on an EP (Engineering & Procurement) contract.
The engineering activities performed by UCSA provided the BDP, the DEP, the coordination of outsourcing detailed engineering services, the complete HAZOP analysis of the revamped plant, from the preliminary release to the final plant configuration required for fulfilling the strictest safety requirements.
The procurement activities consisted of supplying all the itemized equipments (including main spare parts for rotary equipments) and the whole bulk material (structure, electrical, instrumental, piping). Spare parts for two years have also been supplied as part of the contract.
UCSA provided at site also assistance services for construction activities, and supervision services for commissioning and start-up activities.

In the following figure, the UCSA project organizational chart is shown:



Regarding the process, the main disadvantage of urea-melamine plant integration is the surplus of carbammate flow recycled to the urea synthesis loop (about +50% compared to the figures of a stand-alone plant), which has a detrimental impact on the reactor conversion.

Casale opted for revamping the synthesis unit with its High Efficiency Combined (HEC) process, thus providing a technology able to improve the overall CO2 conversion and minimize the modifications in the downstream sections.

A process block diagram of the overall urea plant is illustrated in Fig. 8.

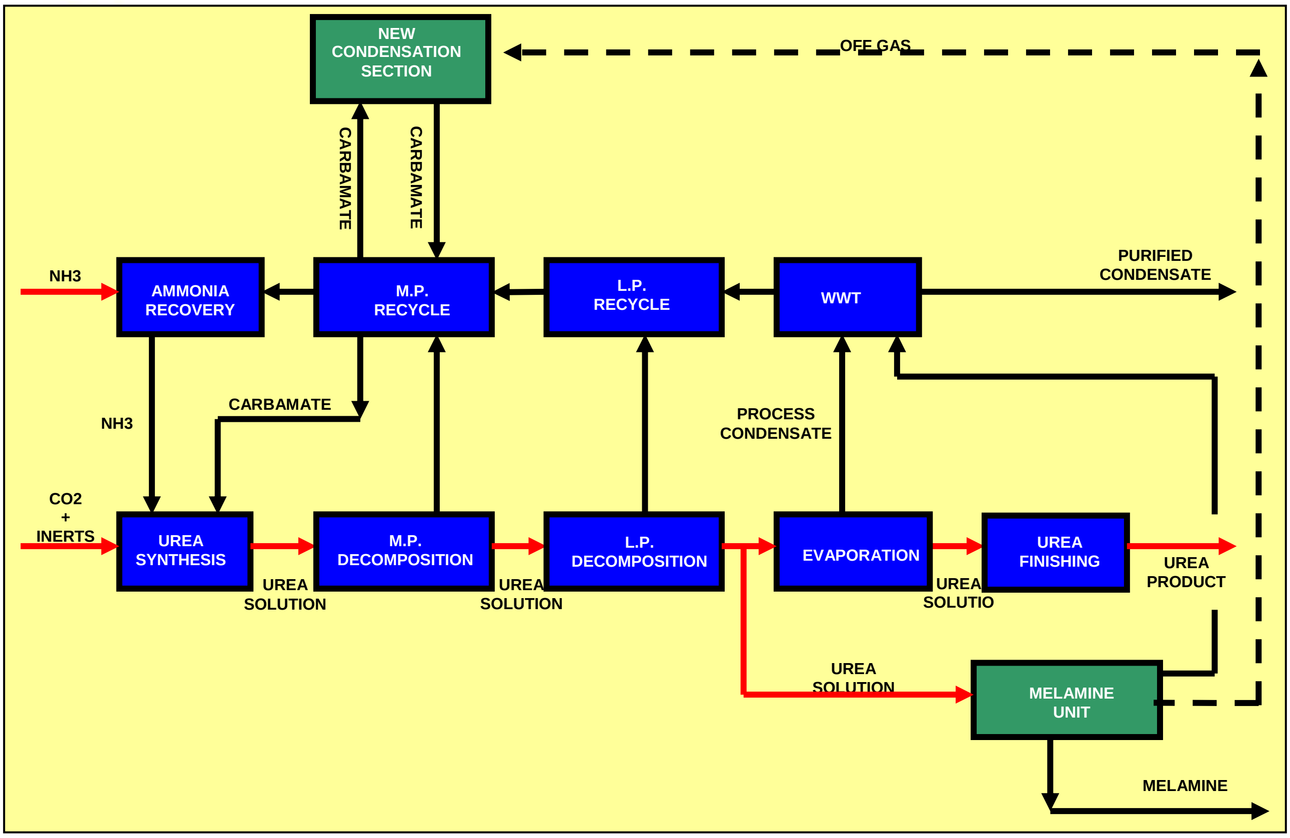


Fig. 8 - Urea Total Recycle Plant integrated with Eurotecnica Melamine

In addition the project provided the implementation of a new process condensate treatment unit, designed accordingly to Casale HEH (High Efficiency Hydrolizer) technology, in order to produce BFW quality treated condensate.

The main modifications were the ones relevant to the synthesis loop:

- New secondary reactor equipped with high efficiency trays
- New stripper
- New Carbamate condenser
- New Carbamate pumps (replacement of existing)

A part from the pure process aspect of providing additional surfaces as well as pumping capacities, the main constrains of the project were the limited space and the limited shut down time available to implement the new installations.
Casale selected to adopt a different approach aimed at improving the synthesis efficiency up to a level where the downstream section would not be significantly affected by the integration with the melamine plant.

The modification of the synthesis loop is shown in Fig. 9,

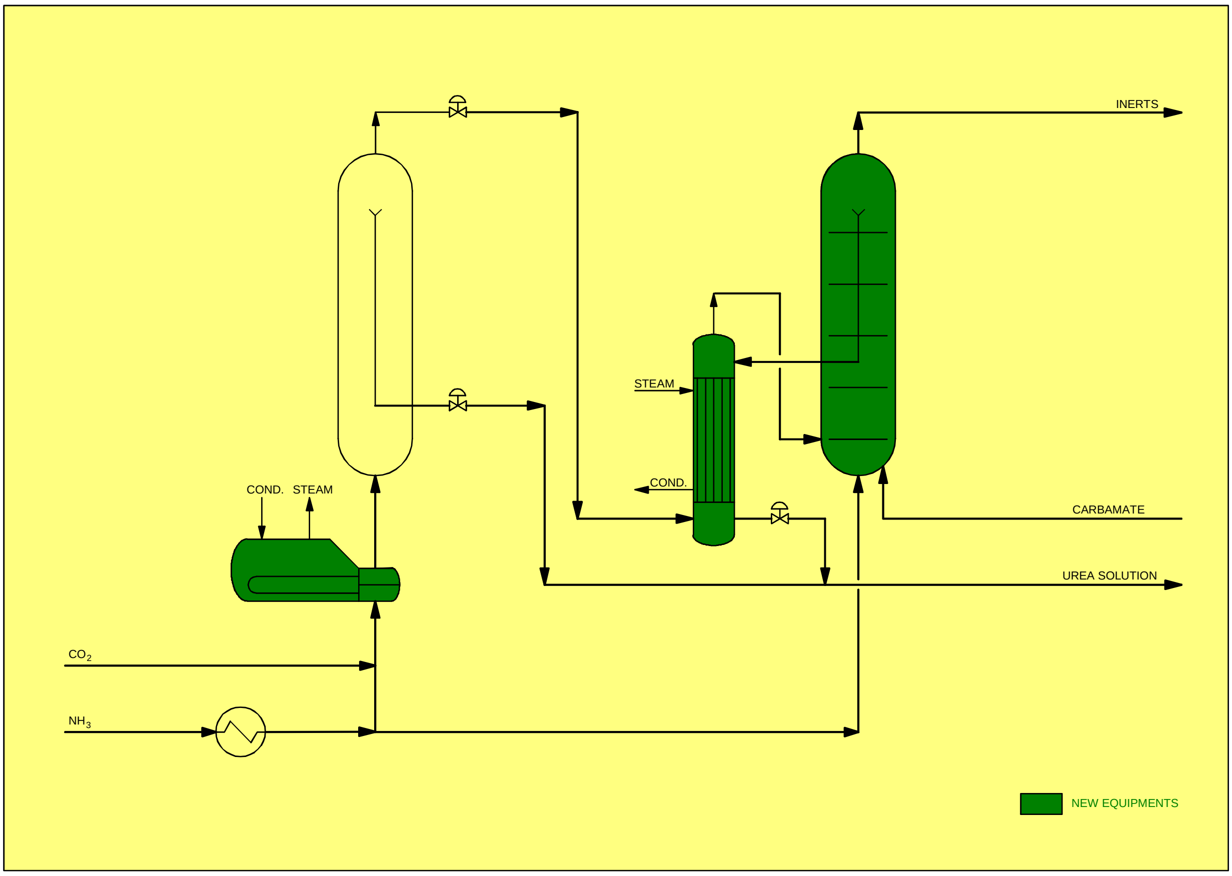


Fig. 9 - New HEC Loop of Total Recycle Urea Plant

In order to improve the synthesis loop efficiency Casale adopted the HEC technology introducing a secondary reactor, with the relevant stripper used as reboiler and using the existing primary reactor with once through configuration together with the new carbamate condenser. The modification led to the fundamental results of obtaining a higher conversion of the loop even if under a drastically worst H_2O/CO_2 ratio. In fact the loop of the stand- alone plant was running with 0.57 H_2O/CO_2 ratio and the conversion of 64% while with melamine integration the H_2O/CO_2 ratio has raised to 0.93, but thanks to the installation of HEC the conversion of the loop has increased to 70%.
The result of this modification is that the medium and low pressure sections do not include significant modifications and the new added HP section can be easily and quickly tied in, thus limiting to the maximum extent the shut down period.

For your reference, please find in the attached table some basic figures of the plants before and after melamine integration.

Parameters	***Unit***	***Before revamping***	***Current without melamine off gas***	***Design[(1)] with melamine off gas***
Synthesis capacity	[MTD]	1300	1320	1610
Carbamate recycle	[kg/h]	67,000	64,900	105,000
Specific carbamate recycle	[kg/ton of U]	1237	1180	1500
Specific HP steam[(2)] consumption	[kg/ton of U]	-	290	400

NH_3/CO_2 loop ratio	-	3.48	3.5	3.58
H_2O/CO_2 loop ratio	-	0.57	0.5	0.93
Overall loop conversion	[%]	64	72.5	70

(1) Melamine plant and off gas recovery not yet in operation
(2) Superheated steam at 27 barg and 400°C

As it is clear from the above table, the introduction of the HEC Casale technology enables the increase of HP loop capacity thanks to the improvement of the synthesis efficiency. The specific carbamate recycle flow has increased by 20% only despite the carbammate flow increased of about +50%, which is a further confirmation of the improved efficiency of the system.
In addition to the above, a new off-gas condensation section was added consisting of L.P. carbamate pumps, off-gas condenser with relevant tempered cooling water system.
The scheme of off-gas condensation is illustrated in Fig. 10.

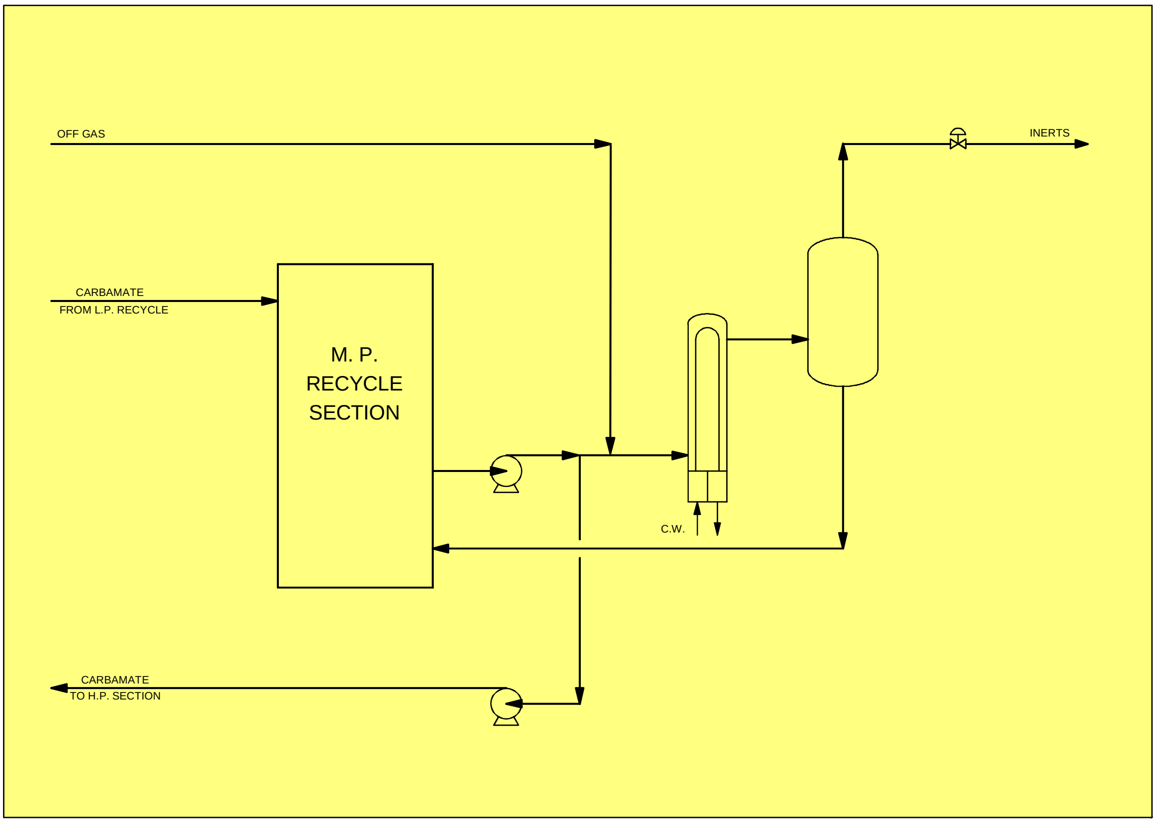


Fig. 10- New Off-gas Condensation Section

Besides the melamine integration the project foresaw the replacement of crystallization with evaporation section and the provision of a brand new waste-water treatment section.
In the enclosed Fig. 11 we show a process diagram of the new waste water treatment sections.

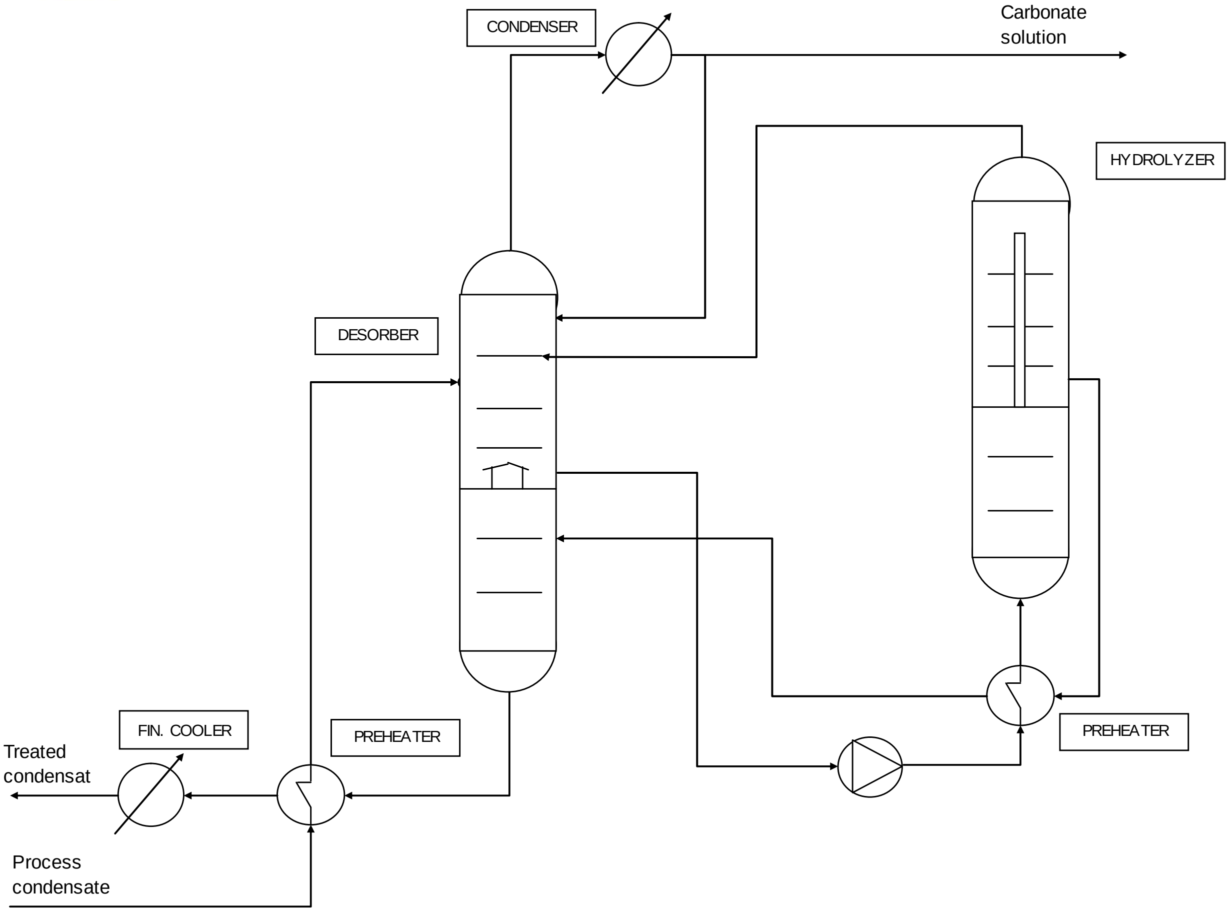


Fig. 11 - New Waste Water Treatment Section

The WWT design is based on Casale HEH (High Efficiency Hydrolizer) technology; the operating pressure of the hydrolizer (using MP steam) is 20 bar about. Since the first operation, the new WWT section has already demonstrated to be able of producing treated condensate suitable for BFW use. In fact the ammonia content has been detected to be approximately 2 ppm while urea is less than 1 ppm.

Case Study 2: Novomoskovsk Azot JSC (NAK), Novomoskovsk (Russia)

An application of Casale Technology for Ammonia Stripping Urea Plant Revamping

At the end of 2006, Urea Casale (UCSA) and NOVOMOSKOVSK JSC AZOT (NAK) signed a Contract for the modernization of Urea Plant no. 3, based on Ammonia Stripping technology and located in Novomoskovsk, Russia.
The purpose of the revamping project was the plant capacity increase from the nameplate load of 1500 TPD up to 2000 TPD.
UCSA was charged for the License, Basic Engineering and the Supply of several critical items, whereas for the Detailed Engineering a local company was selected.
UCSA performed also the assistance at site during the pre-commissioning, commissioning and start-up phases.

In the mean time, in a parallel project NAK has managed also the provision of a new Granulation Unit, designed for the capacity of 2000 TPD as well.

At the end of 2008, the first step of the project was already carried out installing the new stripper and introducing the vapour line from the reactor top to the stripper bottom.
Then the remaining modifications foreseen by the revamping have been implemented step by step during the 2009, and the urea plant performances were tested at full load in November 2009 (when the plant achieved more than 2000 TPD of production).

With the replacement of the old HP stripper in the first step of the project, the main limit was already removed.

Furthermore, NAK in the last months had evaluated also the energetic performances of the Plant, deducing the good results that have been clearly outlined since the first step of the project.

The new HP Stripper and the new HP ejector (supplied by UCSA) bear easily the load at 2000 MTPD. Considering that the HP Section at the moment is being operated at a pressure 15 kg/cm2 lower than the design, it is easy to assume that even higher capacity could be processed.

In the enclosed Fig. 15 it is shown a simplified process diagram of the modified synthesis section.

To sum up the main process modifications were:

- Ø The installation of the new HP Stripper (designed and supplied by UCSA)
- Ø the introduction of a new vapour outlet line from the reactor top to the stripper bottom: in this way the passivation air can be fed directly eliminating the risk of corrosion phenomena;
- Ø the installation of a new level measurement on the reactor top;
- Ø the introduction of a new MP Predecomposer in the MP section, that works accordingly to the design parameters (T outlet= 152 °C): the heater on the shell side is heated by steam provided by a new steam booster installed for consuming the excess of LP steam;
- Ø the installation of an additional vacuum package working in parallel with the existing one;
- Ø the improvement of the waste water treatment system, by installing both a new distillation column and a new Hydrolyzer designed accordingly to HEH (High Efficiency Hydrolizer) Casale technology;
- Ø the improvement of ammonia gaseous emissions through the installation of the new 4 bar Absorber (designed and supplied by UCSA).

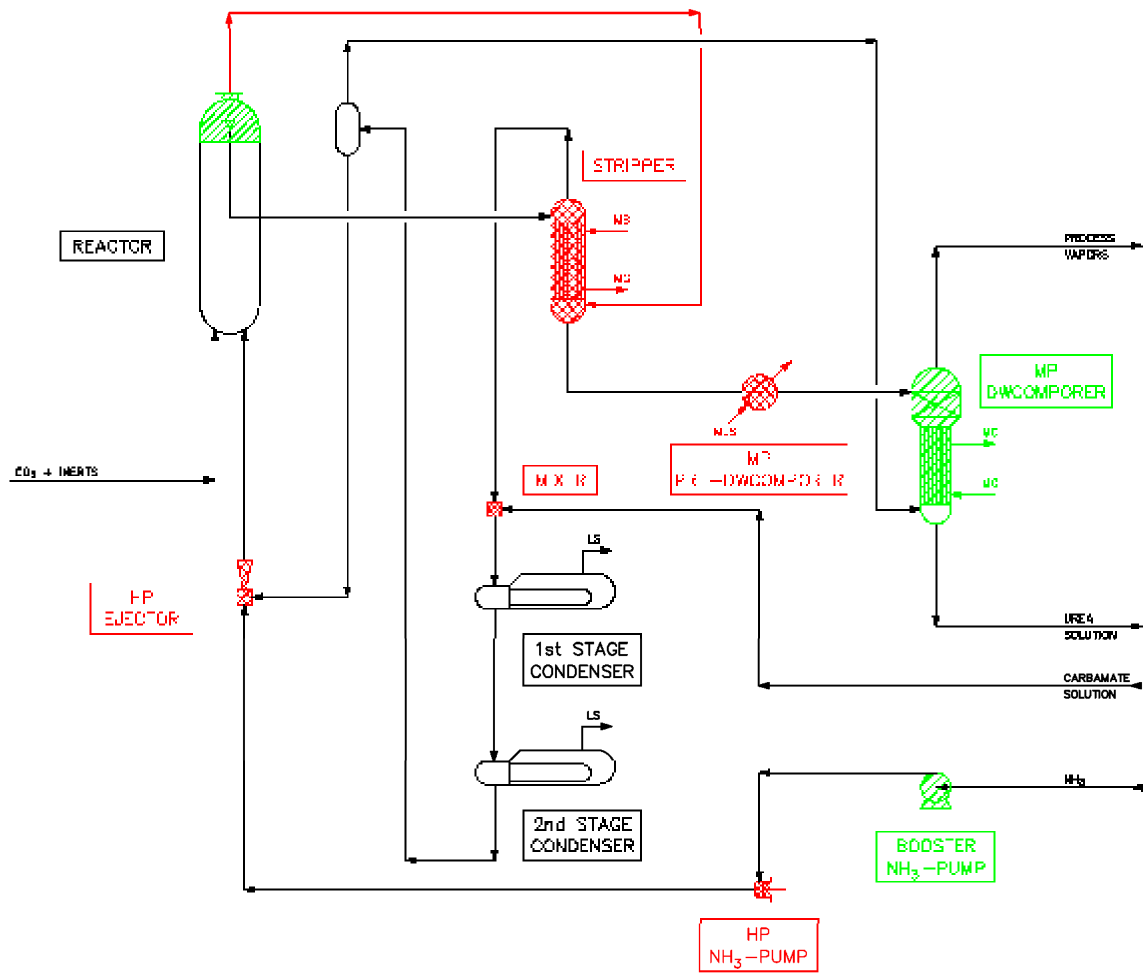


Fig. 15 –Process flow diagram of the Synthesis Section with the new passivation air line to the Stripper

The main performances, compared with the figures before the revamping project, are indicated in the following table:

Synthesis	***Unit***	***Before revamping***	***After revamping***
Capacity	[MTD]	1500	2030
Carbamate recycle	[kg/h]	38,500	61,000
Specific carbamate recycle	[kg/ton of U]	616	720
Stripper steam(1) consumption	[kg/h]	58,000	51,600
Spc. HP stripper steam consumption	[kg/ton of U]	928	610
NH_3/CO_2 loop ratio	-	3.4	3.05
H_2O/CO_2 loop ratio	-	0.6	0.53
Reactor conversion	[%]	55.0	58.1
Reactor pressure	[bar]	-	140

(1) Saturated steam at 23 barg

The data above summarized allow thinking that even higher plant load could be reached, and with good steam consumption.

Conclusions

This paper provided some significant cases of application of Casale technologies to large scale revamping of urea plants and its capability of managing project of significant scale.

Moreover such technologies have been successfully applied for any of the most known urea process licenses in the world.

In particular we have investigated two main cases study: the Toyo Total Recycle plant owned by QAFCO in Qatar and the Ammonia Stripping plant owned by NAK in Russia.

These projects, which have been selected among others just to present some typical revamping approach, show the flexibility of the company in finding the most suitable project strategy for coping with the Clients' need.

The operating parameters observed during the start-up of the mentioned projects are stable and the performances significantly improved compared to the past operation.

Above all, the variety of such projects proves that the experience and the flexibility of our process specialists is able to fix the most profitable solutions customized for the particular need of our Clients.