UREA - MELAMINE PLANTS INTEGRATION, CASALE EXPERIENCE

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Abstract

The paper presents different proposals of integration of urea plants with melamine plants adopted by CASALE according to the different plants typologies and the Clients' requirements.

The integration of the two plants normally also involves a capacity increase of the urea plant.
The unavoidable utilization of the off-gas coming from the melamine plant as raw materials in the urea plant creates, owing to the additional water amount which this recovery involves, a major penalization to the urea plant, heavily affecting the urea plant revamping.

Other important aspects to be considered are the typologies of the existing urea plant to be modified: total recycle plant or stripping plant and the technology of the melamine plant from which the off-gases are coming: at low or high pressure.

Some significant examples of integration between the two plants are also described in the paper.

FOREWORD

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.

The generation of NH_3 and CO_2 is coming from the dissociation of a big part of the urea feed, which is taking place in the melamine formation process.

For this reason, a melamine plant always requires a urea plant that has to reprocess the un-reacted NH_3 and CO_2 and make again urea out of them.

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 (see Fig. 1).

Fig. 1 shows a very generic representation of a urea plant with the synthesis section (where urea is formed), followed by the decomposition section working at lower pressure (where un-reacted NH_3 and CO_2 from the mixture exiting the reactor are separated) and the evaporation section that is separating water from the urea solution.

The un-reacted NH_3 and CO_2 coming from the decomposition section are processed in the recycling section, and sent back to the synthesis section in form of a water solution (carbamate); while the process condensate coming from the evaporation section is treated in a process condensate treatment unit to form clean condensate to be exported and a lean water solution of NH_3, CO_2, which is recycled to the recycling section.

As mentioned above, the melamine plant is generating, similarly to the decomposition section of the urea plant, a stream of NH_3 and CO_2, and unless this stream is released at a pressure comparable to the one of the urea plant synthesis section, it needs to be reprocessed in the recycling section of the urea plant.

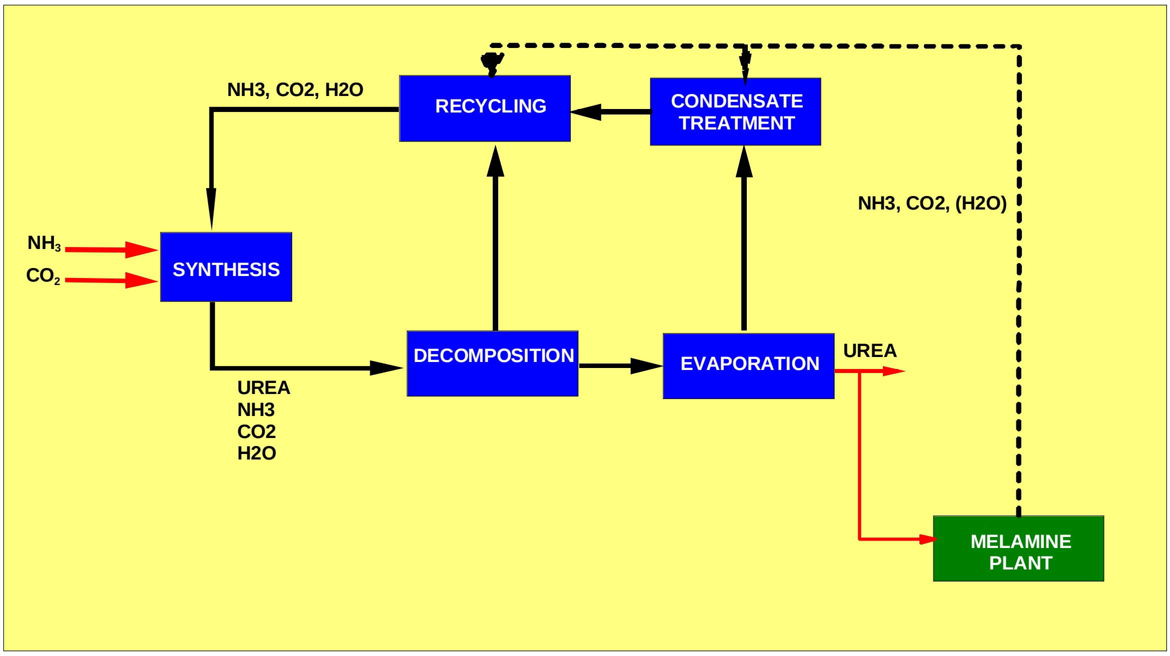

Fig. 1 - Melamine Plant Integrated with Urea Plant

The melamine plant may also generate process condensate to be treated in the condensate treatment section.

The integration of a melamine plant with a urea plant depends on different factors like the melamine and urea plants technology adopted for the specific case, and the ratio of melamine plant to urea plant capacity.

The integration of a melamine plant with a urea plant is generally causing a decrease in the urea plant efficiency and it can be a simple task if the melamine plant capacity is low compared to the urea plant capacity and no capacity increase is required for the urea plant. It can, however, also pose technical challenges whenever it is significantly reducing the urea plant efficiency.

This paper has the objective of providing an overview of the possible scenarios for the integration of a melamine plant with a urea plant, and it is also describing how CASALE technologies can fit to the various specific cases. Moreover, some case histories are described to provide practical examples of typical configurations.

Technical Problem

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.

As the urea plant owner generally wants to maximize urea capacity for a given amount of feed stocks, after the integration with a melamine plant, the urea plant (in particular the synthesis, decomposition and recycling sections) will have to run at a higher capacity due to the additional NH_3 and CO_2, which can be considered as additional fed stocks, coming from the melamine plant (off-gas), which have to be converted into urea.

Moreover, the off-gases are generally produced at a pressure lower than the one of the Urea synthesis, and, therefore, they have to be condensed and pumped back to the synthesis loop pressure. This is overloading the recycling section of the existing urea plant.

The off-gas condensation requires a certain amount of water necessary to keep NH_3 and CO_2 under liquid form.
This fact has two negative effects on the plant efficiency:

- the additional water necessary for the off-gas condensation will be than recycled to the synthesis loop thus decreasing the efficiency of the synthesis itself.
- less fresh feed stocks, per ton of produced urea, are sent directly to the synthesis section. Fresh feed stocks are sent directly to the synthesis section to provide, with their condensation at the synthesis section, heat for the reaction and, eventually, for steam production. A decrease in the specific amount of fresh feed stocks sent directly to the synthesis section is, therefore, negatively affecting the efficiency of the synthesis section and also the heat balance of the plant.

The amount of water depends on the type of melamine technology and on the conditions of the relevant off-gas.

The higher is the melamine plant capacity for a given urea plant capacity the higher will be the above mentioned negative effects of the integration on the efficiency of the urea plant.

The decrease of the synthesis section efficiency leads to an increase of the amount of unreacted NH_3 and CO_2 that will additionally overload the existing sections of the urea plant (especially the decomposition, recycling and condensate treatment sections).

To summarize, the impact of the integration of a melamine plant with an existing urea plant is the following:

- Higher plant capacity is required to transform the NH_3 and CO_2 coming from the melamine plant back into urea.
- 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 amount of additional water that is going to be reaching the synthesis may, in other words, be different, but it will always negatively affect the synthesis section.

Very recently, new melamine technologies have been patented that have the capability to produce the off-gas at the urea synthesis section pressure. This type of technology would have a lower impact on the urea plant.

CASALE Solution Approach

The solution of the technical problems of integrating a melamine plant with a urea plant can be at the end reduced 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.

Through various studies performed by CASALE for the integrations of melamine plants with urea plants, CASALE has developed different designs for the unit that is interconnecting the melamine plant to the urea plant.

These designs are addressing 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.

The design of the off-gas condensation unit is tailor-made to the combination of the type of melamine plant and of urea plant that are interconnected.

Typically, if the off-gas is at low pressure a multi steps condensation design is applied, which foresees a partial re-evaporation to reduce the amount of water that is otherwise needed to condensate the NH_3 and CO_2 rich off-gas stream at low pressure.

If the off-gas is at medium/high pressure, in any case lower that synthesis pressure, the condensation is made always making most efficient use of the water that is already present in the urea process. A proper study is performed to identify the most appropriate source of water within the existing urea plant.

For the second point mentioned above, CASALE disposes of advanced technologies to revamp any kind of urea plants improving to the maximum extent the efficiency of the synthesis section.

The most appropriate of these technologies, whose efficiency have proven in several applications, is selected case by case depending on the type of urea technology, the conditions of the off-gas and the melamine to urea capacity ratio.

An overview of these Casale technologies, which can be conveniently used for integration projects of melamine plants with urea plants, are briefly described in the next section

CASALE Advanced technologies to increase Urea Plants efficiency and capacity

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

For every project involving an integration of a melamine plant with a urea plant, Urea Casale proposes one or a combination of these technologies in order to obtain this integration in the most efficient way.

In this chapter most of the technologies developed by Urea Casale are shortly described.

Casale-Dente High Efficiency Trays

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, its 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.

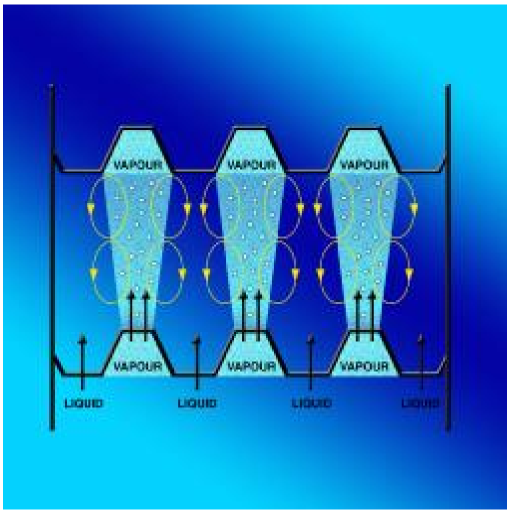

Fig. 2 - Casale-Dente High Efficiency trays

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.
- 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.
They can be also conveniently used to increase the efficiency of the synthesis section of any kind of urea plants that need to be integrated with a melamine plant.

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

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

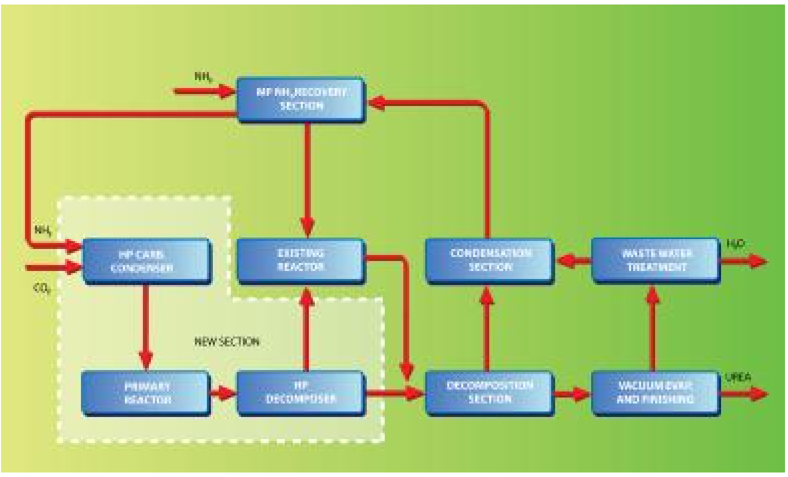

Fig. 3 - Conventional Total Recycle Plant revamped with the HEC Concept

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 unreacted NH_3 and CO_2 directly into the secondary reactor, operating at lower pressure.

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

The capacity of conventional total recycle plants can be drastically increased applying the HEC concept, 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 (see Fig. 3).

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

This technology to the features just described, is suited to revamp conventional total recycle plants if they have to be integrated with melamine plants requiring to boosts the capacity and compensate to the loss of efficiency coming from the integration.

Split Flow Loopä and Full Condenserä concepts

These technologies are a powerful tool to increase the capacity of CO_2 stripping plants in a very efficient, and therefore economical, way.

According to the **Full Condenser**ä concept (Fig. 4), an existing HPCC is modified so that:

- 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 mixed two-phase flow, thanks to its lower density, rises up in most of the tubes and along the tubes the vapors condense.
- A very small amount of tubes are left without vapor phase, producing an internal natural circulation.
- 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 (NH_3 + carbamate) enters the exchanger through the second bottom nozzle and is distributed in all tubes.

Fig. 4 - Full Condenserä configuration

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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.

With the **Split Flow Loop**ä concept (Fig. 5), the HP loop is modified so that:

- the HPCC is practically a total condenser and is fed with only the amount of vapors that actually has to be condensed (i.e. about 2/3 of the total vapor coming from the stripper).
- 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 incondensable inerts leave from the top of the condenser and are sent directly to the scrubber together with the some uncondensed NH_3 and CO_2.
- 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.

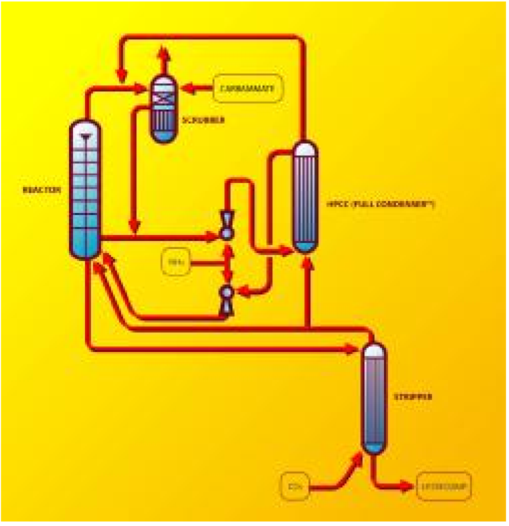

Fig. 5 - Split Flow Loopä **configuration**

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.

Transforming the loop of a CO_2 stripping urea plant into the **Split Flow Loop**ä / **Full Condenser**ä configuration makes it more efficient allowing increasing its capacity up to 50% and reducing energy consumption.
Thanks to these features, the **Split Flow Loop**ä / **Full Condenser**ä configuration is a very powerful tool also to debottleneck CO_2 stripping plants in case of an integration with a melamine plant.

VRS (Vapor Recycle System) process
This technology has been developed for the revamping of stripping plants and is used in certain cases to drastically increase the capacity of said plants.

The VRS concept foresees a separate circulation of recycle water and recycle NH_3 and CO_2, i.e.:

- The carbamate solution obtained in the downstream process sections instead of being sent the H.P. section, is distilled in an H.P. decomposer working in parallel to the existing stripper.
- The vapors thus obtained (containing NH_3, CO_2, and little water) are sent to the H.P. Section (H.P. Carbamate Condenser), while the distilled solution (enriched in water) is sent back to the back-end of the plant.

In this way, practically only the NH_3 and CO_2 contained in the carbamate are sent back to the synthesis section, while the water is almost totally sent back to the recycling and waste water treatment sections.

As a consequence, the H.P. synthesis loop will operate with very low water content with the following advantages:

- very high CO_2 conversion is obtained in the reactor (up to 70%)
- very high stripping efficiency
- lower amount of water to be treated in the existing decomposition, vacuum evaporation and waste water treatment sections.

The existing plant (see Fig. 6) is modified according to the VRS concept adding a new decomposition section in parallel to the existing plant. The HP carbamate is sent to the new section where it is decomposed. The released vapors, rich in NH_3 and CO_2, are sent to the synthesis section, while the purified solution is sent back to the back-end of the plant.

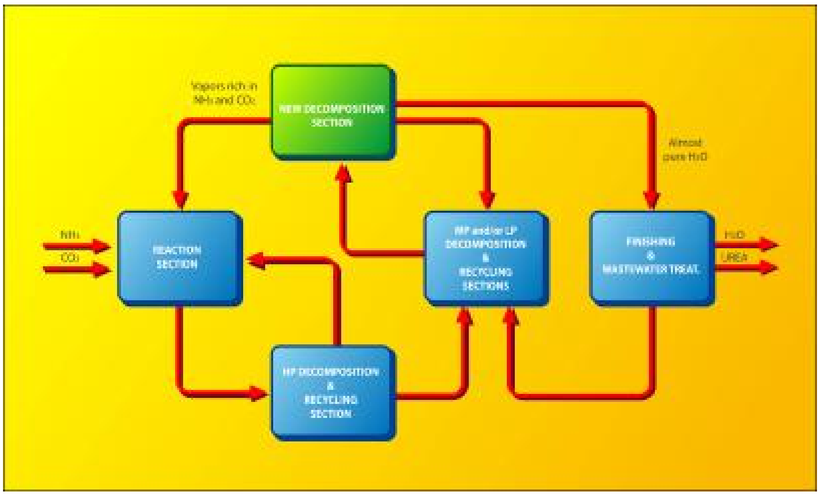

Fig. 6 - Stripping Plant Revamped according the VRS Concept

As the existing reactor will be working with a low water content (H_2O/CO_2 molar ratio of 0.2 ÷ 0.25), a high CO_2 conversion is obtained (66 ÷ 70%).

Due to the fact that, in the existing plant, the new conversion is much higher and the water content much lower than the ones before the modification, the existing plant can, again, be re-utilized at higher capacity with only minor modification.

With this approach, an increase in capacity up to 50% or higher can be obtained.

Using the VRS process, it is possible to reduce the effect of the additional water introduced with the integration with the melamine plant by cutting it off from the carbamate stream. Stripping plants that need to be integrated with melamine plants can be conveniently revamped with the VRS process.

CASALE Experience in Integrating Melamine Plants with Urea Plants

CASALE has performed several studies for the integration of melamine plants with existing urea plants.

Some of those studies have been implemented or are under implementation, CASALE has, therefore, a good experience in integrating different type of melamine plants with urea plants.

This has given CASALE the chance to study different solutions for the unit that is interconnecting the melamine plant to the urea plant gaining also a remarkable experience to study the same also for various types of melamine processes.

The above, combined with a very large and vary experience for the revamping of existing urea plants.

Here below we list the most significant projects and studies that CASALE has carried out or is carrying out in the field of melamine integration to urea plants.

The melamine plants considered in the various projects described in the lists were of different types, such as low-pressure catalytic or high pressure non-catalytic including also the high pressure process.

It is significant to mention that CASALE has also studied the possibility of designing a urea plant dedicated only to the production of urea for the melamine unit, recovering the off-gas from the melamine itself.

CASALE EXPERIENCE FOR INTEGRATION OF MELAMINE PLANTS WITH UREA PLANTS						
	Name of Plant	***Location***	***Original design technology of*** ***- urea*** ***- melamine***	***Synthesis capacity*** ***- Original*** ***- New*** ***(MT/D)***	***Status***	***Scope of Supply***
1	KHORASAN	Iran	- CO_2 Stripping - Eurotecnica	1500 1700	In operation	
2	BASF	Germany	- Total Recycle (Toyo) - BASF	800 1800	Cancelled after basic design	License, Basic Engineering Package. & material supply
3	CONFIDENTIAL	Confid.	- Total Recycle (Toyo) - Eurotecnica	1000 1610	Under Design	License, Engineering & Material supply
4	TRIAD	USA	- CO_2 Stripping - Melamine inc.	1200	Completed	Paid study
5	MELAMINE INC	USA	- New plant - Melamine inc.	(1)	Completed	Paid study
6	FERTIL	RUWAIS (U.A.E.)	- CO_2 Stripping - Agrolinz	1500 2700	Under execution	License, Basic Engineering Package. & material supply
7	LIAHOE	P. R. China	- CO_2 Stripping - Eurotecnica	1620 1970	Completed (on hold)	Study
8	HEJIANG	P.R. China	- NH_3 Stripping - Eurotecnica	1760 2255	Completed	Study
9	CONFIDENTIAL	Holland	- Total Recycle (Toyo) - Low pressure	515 567	On hold	License, Engineering, Material supply and erection

(1) Urea plant designed only for the necessity of melamine unit

Case Histories

This paragraph provides the details of some significant cases of melamine integration with urea plants that have been studied and implemented by CASALE.

The cases that are described have been selected in order to provide a benchmark of the wide range of possibilities that can be faced. In particular three scenarios are considered:

i. Integration of a urea plant with CO_2 stripping process with a Eurotecnica melamine plant with additional increase of urea capacity.

ii. Integration of a urea plant with CO_2 stripping process with a Agrolinz melamine plant with an additional increase of urea production.

ii. Integration of a urea plant with total recycle technology with a Eurotecnica melamine plant with additional increase of urea production.

i. Integration of a urea plant with CO_2 stripping process with a Eurotecnica melamine plant without additional increase of urea production.

The original urea plant capacity was of 1'500 MTD utilizing the CO_2 stripping technology and it was integrated with a 20.000 T/y melamine plant designed with Eurotecnica technology. The off-gases from this kind of melamine unit are made available to the urea plant at medium pressure.

The integration with this type of melamine unit would lead to an increase of urea synthesis capacity of about 13% and of water recycled to the loop of about 15% compared to the figures of a stand-alone plant.

It is, therefore, fundamental to prevent or minimize any further introduction of water in the system in order to avoid detrimental condition of the urea reactor in the urea synthesis loop and to improve to the maximum possible extent, with the minimum investment, the performances of the urea reactor.

The approach of CASALE to the first problem is to maximize the utilization of the water already present in the process in order to ensure the proper condensation of the melamine off-gases. A new condensation section working at a pressure of about 18 bar was designed.

The new section is provided with a condenser and a closed circuit cooling system necessary to remove the condensation heat of the melamine off-gases. The necessary amount of condensing water is provided be the carbamate recycled back from the existing L.P. recycling section.
The condensate from the new section feed the existing H.P. carbamate pumps that recycle the solution to the H.P. loop.

The following table provides the comparison of carbamate parameters before and after the integration.

Parameters	Unit	Before	After	Incr.
Synthesis capacity	[MTD]	1'500	1'700	13%
Carbamate recycle	[kg/h]	37,500	50,000	34%
Specific carbamate recycle	[kg/ton of U]	595.4	705.7	19%
Water flow recycle	[kg/h]	12,300	15,000	22%
Specific water flow recycle	[kg/ton of U]	196.5	211.7	7.7%

As it is clear from the above table, the specific carbamate flow recycle has increased by 19% while adopting the CASALE approach the specific recycled water only by 7.7%.

The second problem, improving the performances of the reactor, has been faced adopting CASALE proprietary technology of High Efficiency Trays that, despite of the increased H_2O/CO_2 ratio in the reactor, has increased its efficiency by more than 1.5%.

The following table provides the comparison of the performance figures before and after the melamine integration project.

Parameters	Unit	Before	After
Total Urea Production	[MTD]	1500	1'700
Prills Urea production	[MTD]	1500	1'500
Urea Solution Production	[MTD]	-	200
N/C ratio	-	3.1	3.2
H/C ratio	-	0.5	0.56
Reactor Conversion	[% wt.]	58.7	60.4
Steam consumption	[kg/ton]	840	830

It is clear that such kind of scheme can be applied only if the ratio between the urea plant capacity and melamine plant capacity is sufficiently high to prevent an extremely high H_2O/CO_2 ratio in the reactor that would otherwise drastically depress the urea reaction, and therefore, the synthesis efficiency. Alternatively a more significant modification of HP loop would be necessary in order to compensate the reactor efficiency reduction.

New installation/modification

As already anticipated, the main goal of the project was to maintain the total prills production, integrate the melamine with urea plant limiting the investment of the project.
The objective was completely achieved both from plant performances point of view, as describe above, and from the commercial one. In fact the adopted modifications were the followings:

- New High Efficiency Trays in urea reactor
- New circulation water cooler for H.P. scrubber
- Additional surfaces on recirculation heater and L.P. carbamate condenser
- Additional atmospheric evaporator and condenser
- Melamine feed pumps.

In addition to the above, the new off-gas condensation section, consisting of L.P. carbamate pumps, off-gas condenser with relevant tempered cooling water system, was added.

The revamped plant, integrated with the melamine plant, is successfully in operation since 2003.

ii. Integration of a urea plant with CO_2 stripping process with a Agrolinz melamine plant with an additional increase of urea production.

The original urea plant capacity was of 1'500 MT/D utilizing the CO_2 stripping technology. The plant is presently running at the overall capacity of 1'800 MT/D.

The client asked CASALE to increase the urea capacity to 1'900 MT/D and to integrate it with a 80.000 T/y melamine plant designed with Agrolinz technology. The off-gases from this kind of melamine unit are made available to the urea plant at high pressure.

The integration with this type of melamine unit would lead to an increase of urea synthesis capacity of about 50% and of water recycled to the loop of about 25% compared to the figures of a stand-alone plant.

In this case, on one end, the off-gases from the captioned melamine unit are produced at high pressure, with a lower water requirement necessary for their condensation, but, on the other hand, the amount of the off-gas is quite high and, therefore, in view also of the required revamping of the urea production, the existing equipment of the H.P. loop would not be in a position to handle the high output (i.e. 2'700 MTP/D) with the present scheme.

CASALE, thanks to its technologies, selected an approach that will save all the equipment of the H.P. loop. The urea reactor is modified installing the CASALE High efficiency Trays, which enables an increase of conversion of about 1.5% even if the reactor is running with higher H_2O/CO_2 ratio (0.52 against 0.43 of stand alone plant), while the H.P. carbamate condenser is replaced for maintenance reasons.

In addition CASALE has introduced its innovative **Split Flow™** / **Full Condenser™** technology that drastically debottleneck the H.P. carbamate Condenser of CO_2 stripping plants, improving at the same time the reactor performances.

To overcome the limiting factor of the existing stripper, CASALE has foreseen a new section, equipped with a decomposer and a condenser, working at about 20 bar.

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

Parameters	**Unit**	**Before**	**After**	**Incr.**
Synthesis capacity	[MTD]	1'800	2'700	50%
Carbamate recycle	[kg/h]	41,300	95,400	130%
Specific carbamate recycle	[kg/ton of U]	551	848	54%
Water flow recycle	[kg/h]	12,900	21,100	63%
Specific water flow recycle	[kg/ton of U]	172	188	9.3%

As it is clear from the above table the specific carbamate flow recycle has significantly increased by more than 50% due to the high melamine plant capacity and the introduction of the parallel unit. On the other hand it has to be underlined that despite of the huge carbamate increase the specific water recycle has been limited to only 9% increase.

New installation/modification

In view of the high capacity of melamine unit (80,000 T/y) and the requirement of increasing the final output of urea product, the project is clearly of a much bigger magnitude compared to the first one presented. Therefore, the modifications and additions are much more extensive. Despite of the above a fundamental target is of preventing the addition of new H.P. equipment, apart from the H.P. condenser that was replaced for maintenance reasons.
CASALE achieved this goal providing its **Split Flow™** / **Full Condenser™** technology together with its High Efficiency Trays.

Some more details of the modifications are listed here below:

- High efficiency trays in the reactor
- New H.P. Carbamate Condenser of **Full Condenser™** design
- New decomposition section, decomposer and condenser with relevant tempered water system
- Additional H.P. ammonia and Carbamate pumps
- Additional CO_2 compressor
- New recirculation heater and additional L.P. condenser
- Melamine feed pumps
- New distillation column
- High Efficiency Trays for urea hydrolyser
- Additional pumping capacity of wastewater treatment unit.

The revamped plant is expected to be in operation in 2008.

iii. Integration of a urea plant with total recycle technology with a Eurotecnica melamine plant without additional increase of urea production.

The original urea plant capacity was of 1'000 MT/D utilizing a conventional total recycle technology. The plant is presently running at the overall capacity of about 1'300 MT/D.

The client asked CASALE to integrate the existing urea plant with a 60,000 T/y melamine plant designed with Eurotecnica technology. The off-gases from this kind of melamine unit are made available to the urea plant at medium pressure.

The integration with this type of melamine unit would lead to an increase of urea synthesis capacity of about 25% and of water recycled to the loop of about 62% compared to the figures of a stand-alone plant.

For this particular case of conventional total recycle plant the impact of the increased water recycle has a higher negative effect than in case of stripping plants.

Analyzing the parameters of the project it was noted that the existing reactor was designed for a stand-alone plant of 1'000 MT/D and after melamine integration it would be running at 1'610 MT/D with increased carbamate flow. It became, than, clear that the reactor

efficiency would have decreased significantly due to reduced residence time and to the increased water content. The reduction of reactor efficiency would have had direct drawback on the downstream medium and low pressure recycling sections that are heavily overloaded.
A conventional aproach of providing additional surfaces as well as pumping capacities, would not only become uneconomical but also hit the main constrains of the project, which are the limited space and the reduced shut down time available to implement the new installations.

CASALE, than, selected to adopt a different approach aimed to improve the synthesis efficiency up to a level where the downstream section would not be significantly affected by the integration with the melamine plant. Moreover the new melamine off-gas condensation unit is added with the objective of maximizing the utilization of the water already present in the process.

In order to improve the synthesis loop efficiency CASALE adopted its High Efficiency Combined (HEC) technology introducing a secondary reactor, with the relevant stripper used as reboiler and working the existing primary reactor with once through configuration together with the new carbamate condenser. The modification leads 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**	**After**	**Incr.**
Synthesis capacity	[MTD]	1'300	1'610	25%
Carbamate recycle	[kg/h]	67,000	100,000	50%
Specific carbamate recycle	[kg/ton of U]	1'237	1'490	20%
NH_3/CO_2 loop ratio	-	3.48	3.58	-
H_2O/CO_2 loop ratio	-	0.57	0.93	-
Synthesis loop conversion	[%]	64	70	6%

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 of a carbamate flow increased of about 50%, which is a further confirmation of the improved efficiency of the system.

New installation/modification

The main modifications are 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)

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.

Besides the melamine integration the project foresaw the replacement of crystallization with evaporation section and the provision of a brand new waste-water section.

The revamped plant is expected to be in operation at end of 2008.

Conclusions

This paper provided some significant cases of application to CASALE technologies to different alternatives of integration between urea and melamine units.

The flexibility and expertise of CASALE specialists, that day by day deals with different plants of different technology, and the wide range of technologies developed and available to CASALE provides the clients the confidence of achieving the required target with the maximum energy efficiency and limited investment.