Integrated approaches to improve the overall profitability of fertilizer complexes

A review of options available and experience gained

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Summary:

Fertilizer producers can reduce consumption and/or increase production of their plants by introducing the various revamping technologies developed by an independent company. In addition, they can upgrade single sections of their plants and have them operating more efficiently using special equipment designs and specific technologies for unit operations.

With a large number of revamping projects successfully carried out in the last decades, Casale is now one the world leaders in plant revamping and its technologies are installed in many ammonia/Urea plants all over the world.

In the following paper you will see some examples of different revamp projects.

Syngas | Ammonia | Urea | Nitrates | Methanol | GTL | Hydrogen
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Integrated Approaches To Improve The Overall Profitability Of Fertilizer Complexes – A Review Of Options Available And Experience Gained

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Finding the optimal integration between the different units of a large fertilizer complex is important to obtain maximal efficiency.

This is even more important in case of revamping existing fertilizer complexes comprising different production units where the proper integration of the action steps will amplify the benefits of tailored improvements in the design, operation, reliability, performance of the single units.

CASALE, the only company worldwide that can combine the longest and most successful experience in plant revamping with a technology portfolio encompassing the entire fertilizer production chain from natural gas up to the final product, has developed various integrated approaches to the design or revamping of large fertilizer complex.

Specific case histories of such approaches, currently under various phases of implementation, are presented and discussed.

FOREWORD

Up to the 1980s, CASALE activities were mainly concentrated in the field of ammonia production technology, though some work was also done early on in the field of methanol production technology. From the 1980s onwards, CASALE invested significantly in technology development, and thanks to a team of highly skilled specialists with long experience not only in the ammonia field but also in the fields of urea, methanol and derivatives, the company resumed the activity in the field of methanol production technology and started working on technologies for the production of urea as well as of hydrogen by electrolysis. With the increasing of business in ammonia, the restarting of activity in the methanol field, and the logical diversification into urea, at the beginning of the 1990s CASALE reorganized itself into a group of four companies, each dedicated to its own particular field of activity.

In 2014, all four companies originally making part of the CASALE Group (namely Ammonia CASALE, Urea CASALE, Methanol CASALE and CASALE Chemicals) merged into a new single company by the name of CASALE SA, driven by the need to simplify the company's structure, in order to better co-ordinate and integrate services, talents and creativity in view of strengthening the market position and improving the competitiveness.

During the course of 2013 and 2014, CASALE concluded two important acquisitions, both from Borealis, namely, the technology for the production of melamine and, subsequently, those for the production of nitric acid, ammonium nitrate, urea ammonium nitrate, phosphates and other key fertilizers.

This move was a significant step in a strategy aimed at expanding CASALE's design capabilities and know-how downstream its traditional sectors of ammonia and urea, which has placed the company in a position to serve the needs of the operators of the entire nitrogen value chain and other fertilizers as well.

CASALE operates through six business units, each focused on one of the company's core products. Four operating divisions provide the resources needed to meet the customers' expectations in the most economically competitive way. This structure ensures maximum flexibility whilst securing a high level of specialized knowledge and expertise in every area.

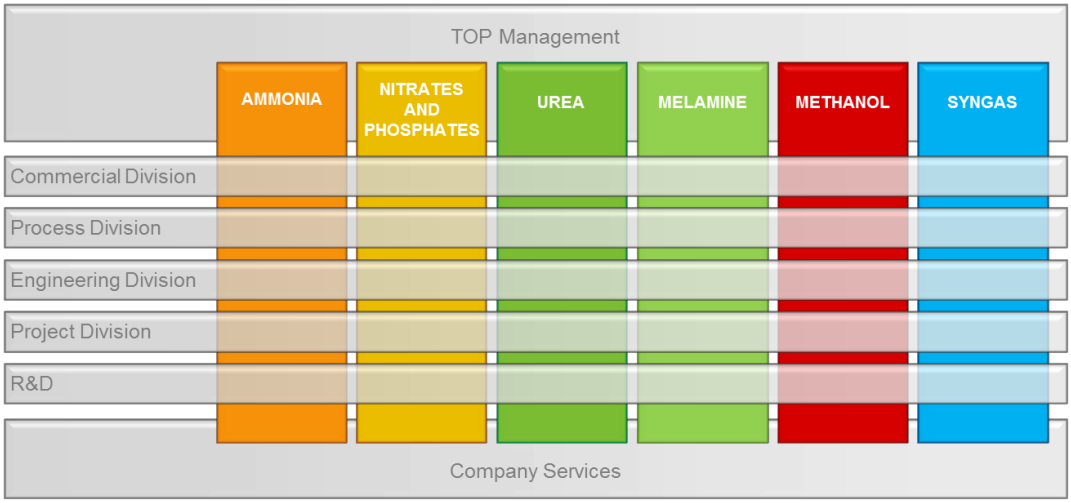

Fig. 1: CASALE structure

CASALE is at the moment the only Licensor able to provide the two complete major routes from synthesis gas:

- Ammonia – Urea – Melamine
- Ammonia – Nitric Acid – Ammonium Nitrate

Such a complete technology portfolio allows to satisfy any Client need in terms of products combination. Moreover, this is accomplished in all the project phases, since CASALE follows the full range of engineering services, from feasibility studies to basic, FEED and detail design.

These technologies are quite different in terms of process and plant engineering specialization, thus it is very unique to have them under the same umbrella.

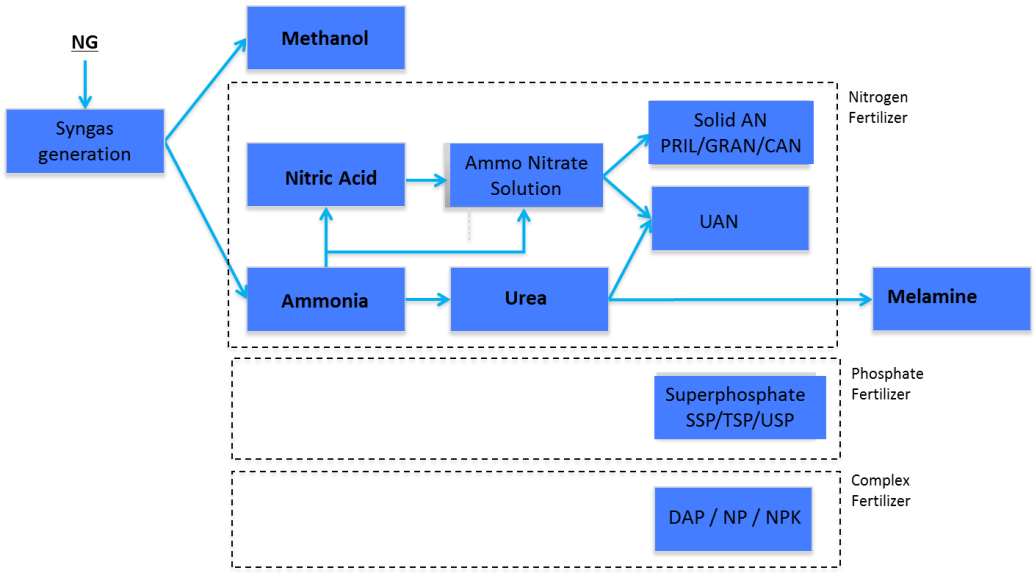

Fig. 2: CASALE technology portfolio

A wide technology portfolio offers the opportunity to exploit synergies between different products, integrating the different units.

This paper introduces the different levels of integration that can be achieved and the advantages that the final Client can obtain from this integration. Moreover, some real cases of integrated project are presented.

POSSIBLE LEVELS OF INTEGRATION AND RELATIVE ADVANTAGES

Essentially, two types of integration are possible: at process level and at engineering level. The integration at process level has impact on the plant design, better exploiting the synergies between the different units. The integration at engineering level has impact on the project execution, improving the interaction between Licensor, EPC Contractor and End User.

Integration At Process Level

The fundamental integration occurs at process level, aiming at optimizing the common networks, easily managing recycle streams and combining common sections.

Having all the technologies under a single Licensor allows to consider the full complex as a whole. This leads to the optimization of all common networks, such as steam generation and distribution, cooling water distribution and utilities in general.

For instance, steam required for Urea plant could be efficiently generated in ammonia synthesis loop. Excess steam generated in the Urea unit can be exported to the steam network of the Melamine unit. Some cooling water exchanger can be put in series to minimize installed exchange surface, such as turbine steam condensers and refrigerant ammonia condenser. Condensate recovery header can be common.

The flexibility in utility network optimization could be very useful in case of non-standard situations, for example where new plants need to be integrated in an existing industrial complex. In this case steam levels are typically constrained by existing grid but CASALE can adapt and optimize the design of all the new units to accommodate the request.

Another important feature of the integration at process level is to completely avoid duplication of unit operations in the different plants, maximizing the synergy.

Some possible interactions beween Ammonia and Urea plants are:

- Use of Ammonia process air compressor for Urea passivation air and Urea granulation air
- Recycle of CO2 compressor interstage condensate in Ammonia plant process condensate stripper
- Use of Ammonia refrigeration section for Urea granulation needs
- Use of Ammonia and Urea plants low grade heat to produce chilled water in a single unit, to be exploited in both plants

- Possibility to send high pressure ammonia directly from synthesis loop, avoiding high pressure ammonia pumps

Also Melamine and Urea units are fully integrated from the point of view of utilities and from the point of view of the raw materials and intermediate streams:

- Ammonia is fed to the Melamine unit directly from the discharge side of the HP Ammonia Pump that feed the NH3 to the Urea Reactor. No additional pump is required.
- CO2 is fed to the Melamine unit directly from the discharge side of the Centrifugal Compressor. No additional compressor is required.
- Molten urea is fed to the HP Scrubber of the Melamine unit by means HP Urea Melt Pump that is fed directly from the Urea Melt Pump.
- Off-Gas from the Melamine unit is fed directly to the HP Synthesis of the Urea unit where it is condensed at high pressure with steam generation.
- Carbonate solution from the Melamine unit is recycled to the LP section of the Urea unit directly from the discharge side of the Desorber Reflux pump. No additional pump is required.

Finally, integration at process levels means managing in the most effective way recycles from downstream plants. This aspect is particularly evident in the Urea-Melamine integration. CASALE has studied and developed an optimized integrated process which produces melamine from ammonia and carbon dioxide taking advantage of the superior process features of the HP Low Energy Melamine (LEM™) process and the advanced concept of Urea Split Flow and Full Condenser Process. The combination proposed by CASALE is the only arrangement that, at present, would allow designing the off-gas treatment section for the melamine plant as if it would be a standard urea production starting from 100% fresh liquid NH3 and gaseous CO2 feed. This is possible since off-gases are produced off-gas at high pressure and water free.

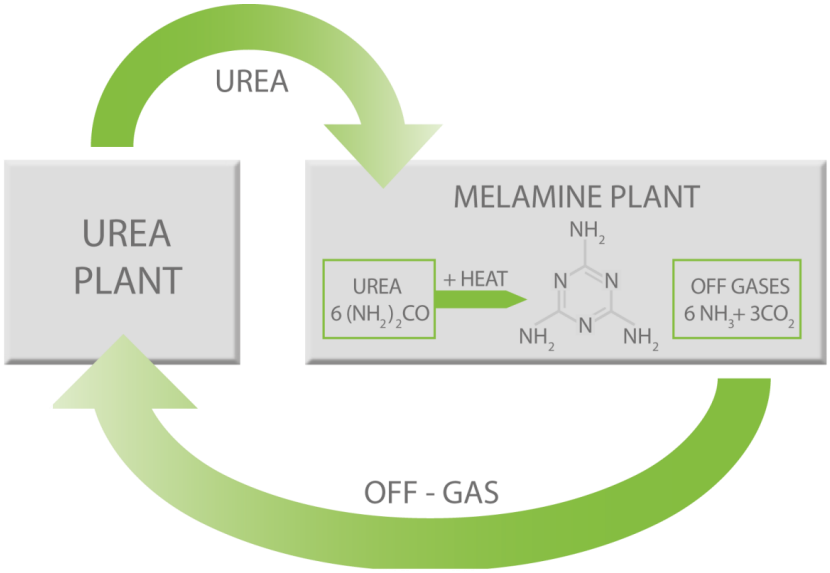

Fig. 3: Melamine and Urea units are fully integrated

In summary, the advantages coming from process integration are essentially:

- Maximum energy efficiency, assuring lowest specific energy consumption. CASALE philosophy is always to enhance the performances by conceiving more efficient process flow configurations or by installing high efficient equipment.
- Minimum investment cost, avoiding duplication of units and managing common utilities to minimize all equipment sizes.

Integration At Engineering Level

Integration also occurs at engineering or project level: being Licensor of all the technologies of the fertilizer complex, CASALE is able to provide uniform engineering documentation for all the production units with common formats and consistent engineering criteria. This could be a great facilitation for EPC contractors

working with CASALE License, minimizing time for information transfer, and for final End-Users, receiving a process plant with uniform design.

Moreover, CASALE can be a real single point responsibility: if a single company is selected for engineering design and technology supply of all units, project efficiency is increased and coordination work by Client and/or EPC contractor is minimized.

The advantages arising from the integration at engineering or project level are:

- Elimination of time loss because of information transfer, that is necessary when several parties are involved.
- No need for iteration between different Licensors with a sensible reduction of project duration.
- Process guarantees are provided by a single entity, avoiding any conflict of responsibility.

CASE HISTORIES

Four case hystories are here after presented, 2 related to revamping projects and 2 related to new grassroot projects. All are clear examples of the benefits of both process and engineering integration described in above paragraph.

Revamping Of 3 Ammonia-Urea Complexes In India

CASALE has been selected by a major Indian fertilizer producer to revamp as many as 5 ammonia plants and 8 urea plants, at three different sites of the same Owner. The ammonia and urea plants were not originally designed by CASALE and some of them were already revamped in the past by other licensors.

The goal of the project, which is presently in construction phase, is reducing the energy consumption. Under the deal, CASALE is providing licensing, basic engineering design, proprietary equipment and technical site assistance.

This is a major undertaking as the plants in questions represent about 16% of India's total installed ammonia capacity and 18% of urea, particularly in consideration of the very fast track approach requested by the Owner. The revamping of all plants shall be started during the course of 2016. CASALE could ensure this goal being a single point of responsibility for the whole complex, thus reducing project duration.

Major energy consumers in Ammonia plants ISBL will be modified or revamped: CO2 removal, compressors, turbines, primary reformer.

The project also marks one of the first cases in which an integrated approach will be followed whereby the revamping of each ammonia and urea complex, plus their respective off sites, will be considered as a whole.

Outstanding results are expected: even in a modern complex, more than 5% total energy reduction is expected, with production of 6400 MTD of Urea at less than 5.2 Gcal/MT.

Revamping Of Ammonia-Urea-Utility Complex In India

CASALE has recently acquired a major contract for the provision of Basic Engineering Design services regarding the revamping of an ammonia-urea-utilities complex in India of an important private fertilizer producer. In addition, a new granulation unit based on CASALE's VORTEX™ technology will also be supplied.

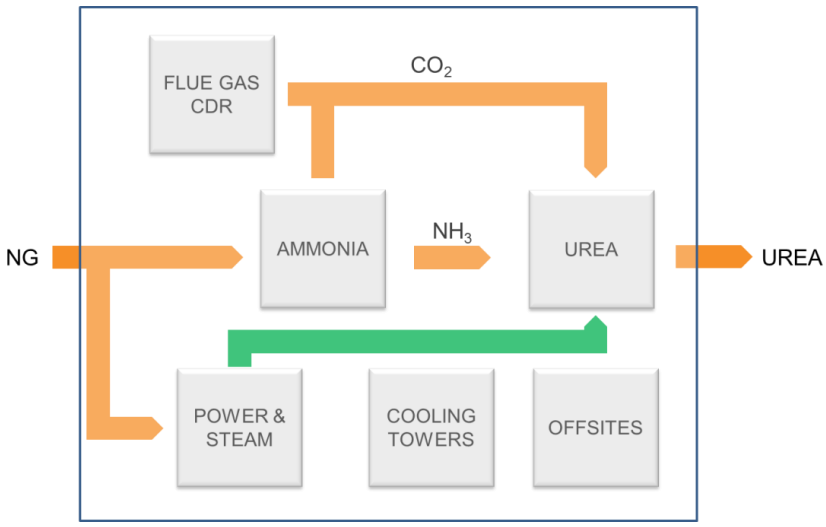

Fig. 4: CASALE process battery limits in an Ammonia-Urea complex

The goal of the revamping is to increase the output of the complex from 850 MTD to 1050 MTD of ammonia and from 1450 MTD to 1800 MTD of urea respectively and at the same time substantially decrease the energy consumption.

This extensive revamping will modify ammonia, urea, product finishing and utilities (with the installation of a new power/steam cogeneration unit) to increase plant capacity and decrease energy consumption. The basic revamping concept is the so-called “Save NG”, specifically devised for the Indian market: extensive electrification of the machines and efficient electricity and steam generation in the utility section. This revamping concept can be applied to any plant, in a more or less pronounced way.

It is clear that this approach can be proposed only by a Licensor able to manage the fertilizer complex as a whole, integrating all the different sections to maximize the efficiency.

New Urea-Melamine Complex In India

In 2015 CASALE entered into a contract for the Basic Engineering Package, Proprietary Item supply and Detail Engineering Design review for a forty thousand (40’000) metric tons per year (MTPY) Melamine unit and for an Urea unit having a capacity equal to gross urea requirement for melamine production plus 50’000 MTPY of additional Molten Urea capacity (for existing melamine plants), using additional raw materials from grid.

This project is a clear example of CASALE technology integration capacities between the well reference experience in the Urea field and the recent melamine technology acquisition. In fact the new industrial plant is having as raw materials liquid ammonia and gaseous carbon dioxide from the existing ammonia plants with the final product being only melamine.

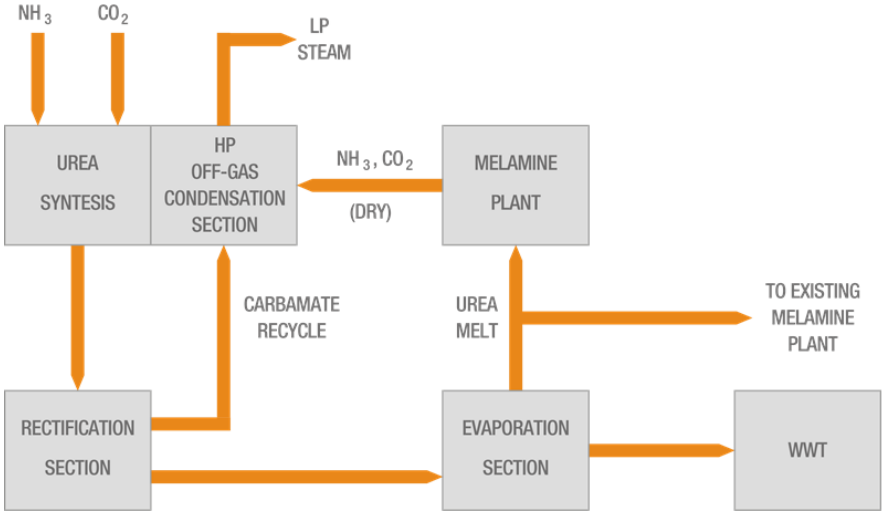

Fig. 5: Overall block diagram of Melamine and Urea units

CASALE was selected due to the extraordinary low energy consumption of Casale LEM™ technology and also to the outstanding integration between Urea and Melamine production units that Casale could propose thanks to its long term and proven capabilities in the Urea plants design.

The production of urea starting from NH3 and CO2, which come in a significant amount (ab 53%) from the off-gas of a melamine production, in form of a liquid stream, and only partially (47%) in form of fresh liquid NH3 and gaseous CO2 feed, can be quite different than a standard urea production starting from 100% fresh liquid NH3 and gaseous CO2. In virtually all the existing melamine plants, the Off-Gas treatment unit is integrated in quite large urea plants in order to minimize the amount of NH3 and CO2 coming from melamine off-gas in comparison to the fresh liquid NH3 and gaseous CO2. This concept does not apply to CASALE design where Melamine Off-Gas is at high pressure and water free, thus equivalent to fresh feed.

Raw material consumption is practically stoichiometric (810 Kg of NH3/T of Melamine, 1080 Kg of CO2/T of Melamine).The extraordinary results is coming from the overall energy consumption of 6.1 Gcal/T of Melamine which include the consumption of all utilities (Steam, Natural Gas, Electricity) necessary for the Melamine production.

New Ammonia-Urea Complex In North America

CASALE has executed the Process Design Package for a large Ammonia Loop plus Urea plant in North America to be included in an integrated gasification combined cycle power plant (IGCC). The plant is supposed be built by a local well reputed EPC contractor.

Feedstocks for the Ammonia Synthesis Unit will be high purity hydrogen from the Pressure Swing Adsorption (PSA) in the syngas production area and nitrogen from the Air Separation Unit. The Ammonia Synthesis Loop will operate at two distinct capacities. The highest quantity of hydrogen gas feed to the Ammonia Synthesis Unit will be available when the IGCC plant operates in an “off-peak” power production mode. This operating case determines the sizing of the Ammonia Synthesis Unit. When the IGCC plant operates at the peak power demand mode, the quantity of hydrogen available for the Ammonia Synthesis Unit will be reduced to 60% of the “off-peak” mode case.

The Urea Unit will produce two product streams: Urea Melt (99.7% wt.) from Evaporation Unit to Pastillation and Urea Solution (80.0% wt.) from dedicated Evaporation Unit to UAN Unit.

In this particular project, the level of process integration was intentionally quite low since the two production units have independent operating conditions: ammonia production is depending on the feedstock availability, while urea production is constant. On the other hand engineering integration was very important and CASALE was selected also because it is a single point of responsibility for the EPC contractor.

CONCLUSIONS

Finding the optimal integration between the different units of a large fertilizer complex is important to obtain maximum results, both in revamping projects and grassroot plants.

CASALE is at the moment the only Licensor able to provide the two complete major routes from synthesis gas able to act as a real single point of responsibility towards the EPC contractor and/or the final End User.

Two types of integration are possible: at process level and at engineering level. The integration at process level has impact on the plant design, better exploiting the synergies between the different units. The integration at engineering level has impact on the project execution, improving the interaction between Licensor, EPC Contractor and End User.

Both these levels of integrations contribute to a successful project.