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# STAMICARBON REVAMPING STRATEGY IN CHINA

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## SUMMARY

**With many urea plants in China operating at maximum capacity, revamping is a challenge way of increasing capacity at minimum cost. As a urea licensor for more than 55 years, Stamicarbon has both the know-how and the experience to develop tailor-made revamp schemes with capacity gains reaching as high as 100% of the original capacity. Stamicarbon has completed over 70 revamp projects worldwide. Recently in China, Stamicarbon has successfully revamped the Yuntianhua urea plant. Stamicarbon was also awarded the revamp of the Petrochina Daqing urea plant. For both plants, the capacity is increased from 1620 to 2300 mtpd. This paper will show how the different revamp schemes can suit different capacity gains.**

**Furthermore, in November 2003, Stamicarbon had been awarded the revamp of Petrochina Ningxia's ammonia stripping urea plant to increase its plant capacity also by about 50%. This paper will focus on all these three debottlenecking projects**.

## 1. PREFACE

Stamicarbon has more than fifty-five years experience in designing and innovating the urea process. These process innovations are a result of theoretical know-how and practical experience. Stamicarbon's parent company, DSM, operates a modern urea plant, based on Urea 2000*plus*™ Pool reactor technology.

With over 200 urea projects realized and a global nameplate capacity share of around 45%, Stamicarbon is the world market leader in Urea. Activities include process licensing of new plants, improvement of existing units and wastewater treatment facilities. Stamicarbon licenses its $CO_2$ Stripping Process and its new urea 2000*plus*™ Technology through Licensed Contractors, which are Chemoprojekt, Chiyoda, Foster Wheeler, KBR, Tecnimont and Uhde.

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The first Stamicarbon $CO_2$ stripping Urea plant started in 1967. Many others followed. Today's plants are highly automated with capacities of up to 3250 mtpd. The new Urea 2000*plus*™ Pool condenser Technology has successfully been in operation at Karnaphuli Fertilizer Company in Bangladesh since 1994, while the Urea 2000*plus*™ Pool reactor Technology has successfully been started up at DSM, The Netherlands, in March 1998. The Stamicarbon processes have a simple design with a minimum number of steps and equipment, keeping investment costs low.

Existing urea plants can be revamped to raise their capacity by 30-50% above original nameplate design. Capacity at Saskferco Products Inc. in Canada was raised from 2000 mtpd to a design capacity of 2850 mtpd, and is currently operating higher than 3000 mtpd. The plant was producing stably and efficiently well above the design capacity rate very soon after start up. The Saskferco plant is the first plant in the world, which has produced above one million tons of product within a year. This is not only a world production record but it proves also the reliable and stable operation of our process.

Stamicarbon Services realized more than 70 revamp projects in different kinds of urea plants. Stamicarbon Services can assist in procurement services for new high pressure equipment items, corrosion inspections during shut-downs in high and low pressure equipment items, troubleshoot and optimization sessions and all kinds of other mechanical and process related services.

## 2. INTRODUCTION

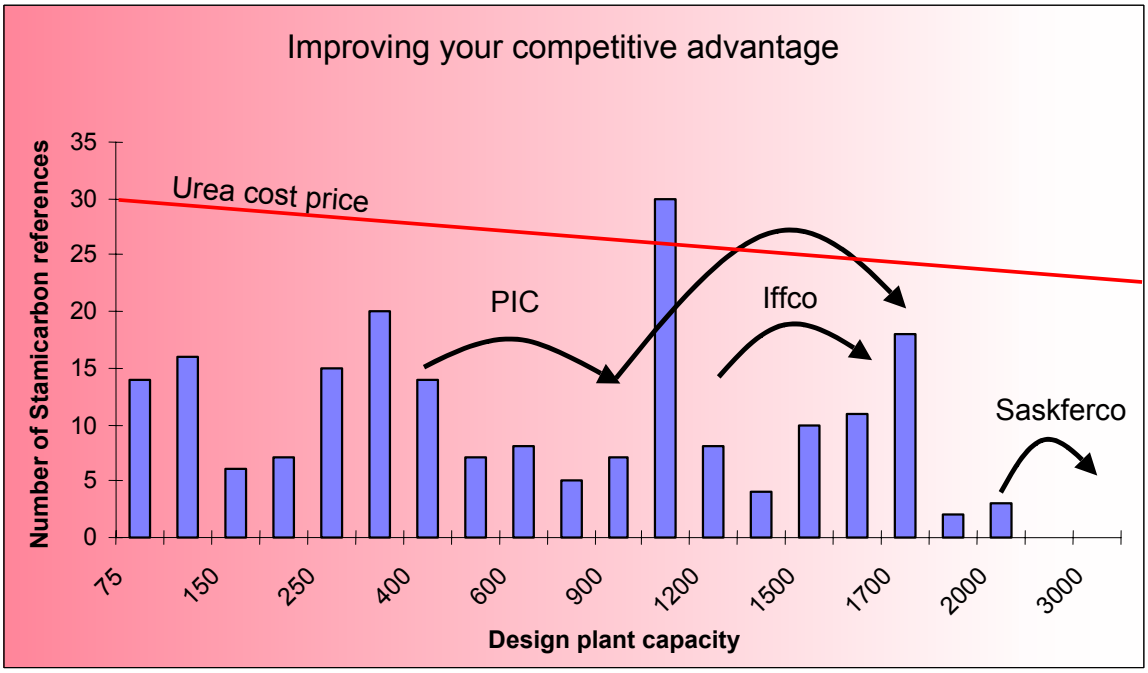
A revamp can cover elements like increase of plant capacity, reduction of the $NH_3$ consumption and emissions to the environment, product quality improvement and energy optimization. Stamicarbon has carried out each of these elements combined in one revamp project or, as the case may be, in separate projects.

When the present operation of the urea plant should be integrated into the revamp, Stamicarbon performs a revamp study, in order to examine the present performance of the plant and to investigate the optimum solution for the revamp and integration with the original plant design.

It is important to consider a debottlenecking or revamp project because it is very attractive to take full advantage of all the design margins available in order to produce more urea. This will lead to a maximum production level in a rather costly process installation.

A higher production level will be achieved with the same number of people, the same infrastructure and the same buildings. The total fixed costs can be divided by more tons of urea leading to a lower cost price. This is also a reason why nowadays the sizes of grass root plants are growing significantly.

**Figure 1. Shows an overview of the Stamicarbon references together with their design plant capacities [status 2001].**




In the sixties, urea plants with a design capacity of 100 mtpd were common while nowadays more than 2000 mtpd and even more than 3000 mtpd are considered normal. Because of the higher capacities the cost price of urea decreases considerably. This means that a debottlenecking project will improve the competitive advantage of such a plant.

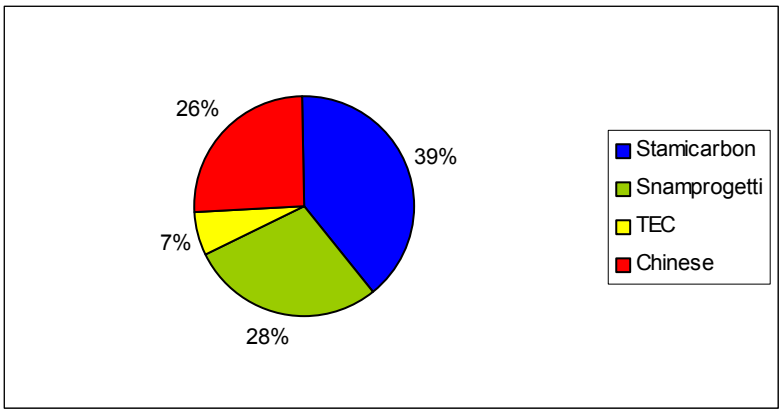
Figure 1 shows just a few examples of clients who have increased the plant capacity through a debottlenecking project. Clearly it is shown how these clients improve their competitive advantage and become or remain leaders in the competitive field.

The other side of the coin is that doing nothing in a urea plant means in fact a deteroriation of competitiveness because other urea plants will execute optimization projects.

Finally a debottlenecking project can be realized against a significant lower investment per ton of urea than a grass root plant. Some examples will be elaborated in this paper.

There are nearly 200 urea plants in China; some 46 of them have a plant capacity higher than 200 ktons a year. The market share of each licensor is shown in Figure 2.

**Figure 2: Market share in China (> 200 kt/year)**




The first Stamicarbon urea plant in China was a conventional type urea plant, with a design capacity of 500 mtpd, designed for Lutianhua in 1963. In the seventies and eighties Stamicarbon designed a row of 15 urea plants with capacities of 1620 and 1740 mtpd.

Table 1 provides an overview of Stamicarbon's activities in China during the last ten years.

**Table 1: Overview of Stamicarbon projects in China during the last 10 years**

| **New plants** | | |
|---|---|---|
| **Year** | **Capacity [mtpd]** | **Client** |
| 1995 | 870 | Heilongjiang Chemical Industry Corp., Qiqihar |
| 1997 | 1050 | CNCCC, Zepu Petroleum Chemical Plant, Xinjiang Petroleum Administration Bureau, Zepu, Xinjiang Province (Pool condenser) |
| 2001 | 2700 | CNCCC, CNOOC, Zhonghai Petrochemical, Dongfang, Hainan Province (Pool condenser) |
| **Revamp projects** | | |
| **Year** | **Capacity increase [mtpd]** | **Client** |
| 2000 | 680 | Yunnan Yuntianhua Co. Ltd, Shuifu, Yunnan |
| 2003 | 680 | China Petroleum Material & Equipment Corporation, PetroChina Daqing Petrochemical Company |
| 2003 | 870 | China Petroleum Material & Equipment Corporation, PetroChina Ningxia Petrochemical Company (Pool condenser) |

While discussing joining the WTO, Chinese producers clearly realized already the need to improve their competitive position. This statement is underlined by the fact that more than ten granulation plants were implemented and several coal gasification projects were built.

During the last three years, Stamicarbon has been awarded three major debottlenecking projects in China all involving a capacity increase of about 50%.

All three projects apply different debottlenecking technologies. This paper explains why.

## 3. OVERVIEW OF STAMICARBON DEBOTTLENECKING TECHNOLOGIES

As nearly all urea plants are different, Stamicarbon has developed several different revamping concepts to offer the most economic scheme meeting all clients' expectations.

Table 2 provides an overview of the Stamicarbon Debottlenecking Technologies together with the expected capacity increase:

**Table 2: Stamicarbon Debottlenecking Technologies**

| Debottlenecking Technology | Expected capacity increase [%] |
|---|---|
| **More In More Out** | **10 - 25** |
| In-line medium-pressure recirculation | 15 - 30 |
| Carbon dioxide carbamate stripper | 20 - 35 |
| Double Stripper | 35 - 45 |
| Medium Pressure Add-on | 35 - 50 |
| Pool condenser/ combi-reactor | 40 - >100 |

Note: The reference for the given capacity increase is the original nameplate capacity.

All technologies offered are based on proven technologies and are developed keeping in mind a simple and reliable operation. All schemes can be implemented during a normal turnaround period. High Efficiency Trays are a standard part of any debottlenecking scheme.

This paper describes three debottlenecking projects awarded recently in China.

Two projects (Yuntianhua and Petrochina Daqing) are both original Stamicarbon $CO_2$ stripping plants urea plants that started production at the end of the seventies with an original design plant capacity of 1620 mtpd, operating both at about 110% of their original design capacity. Both clients asked to increase the plant capacity to 2300 mtpd. At Yuntianhua, Stamicarbon proposed the Double Stripper Debottlenecking Technology while at Petrochina Daqing, Stamicarbon proposed the Medium Pressure Add On Debottlenecking Technology.

The third project is for Petrochina Ningxia and involves a relocated $NH_3$ stripping urea plant with an original design capacity of 1500 mtpd, which was already debottlenecked to 1740 mtpd. The client asked to increase the capacity further to 2610 mtpd. For this project, Stamicarbon proposed the Urea 2000*plus*™ Pool condenser Debottlenecking Technology.

## 4. REVAMP CASES: YUNTIANHUA AND PETROCHINA DAQING

Yuntianhua and Petrochina Daqing both operate a Stamicarbon $CO_2$ stripping urea plant started up respectively in 1979 and 1978 with a design plant capacity of 1620 mtpd. Both plants were running at about 10% above nameplate capacity. At that time these plants were part of a row of eight Stamicarbon urea plants built in China at the end of the seventies.

Both clients installed a hydrolysis unit to reduce the ammonia and urea content in the wastewater to less than 5 vol-ppm. In the nineties Urea Casale was involved in a revamp project at Yuntianhua to install, amongst other items, high efficiency trays.

### 4.1 Yuntianhua

In 2000 Yuntianhua requested Stamicarbon, amongst others, to offer a technology to debottleneck the urea plant to a new design capacity of 2300 mtpd. Stamicarbon proposed the Double Stripper Debottlenecking Technology, which was already well proven at Saskferco in Canada.

At the same time the client awarded Hydro Fertiliser Technology to design a 2300 mtpd granulation unit, with the request to keep the prill tower available for the production of prills.

Further the existing high-pressure carbamate condenser needed to be replaced because of end of lifetime conditions. The original stripper was already replaced identically some years earlier. Finally the debottlenecking project had to be implemented in such a way that the necessary modifications could be implemented during a normal annual turn around.

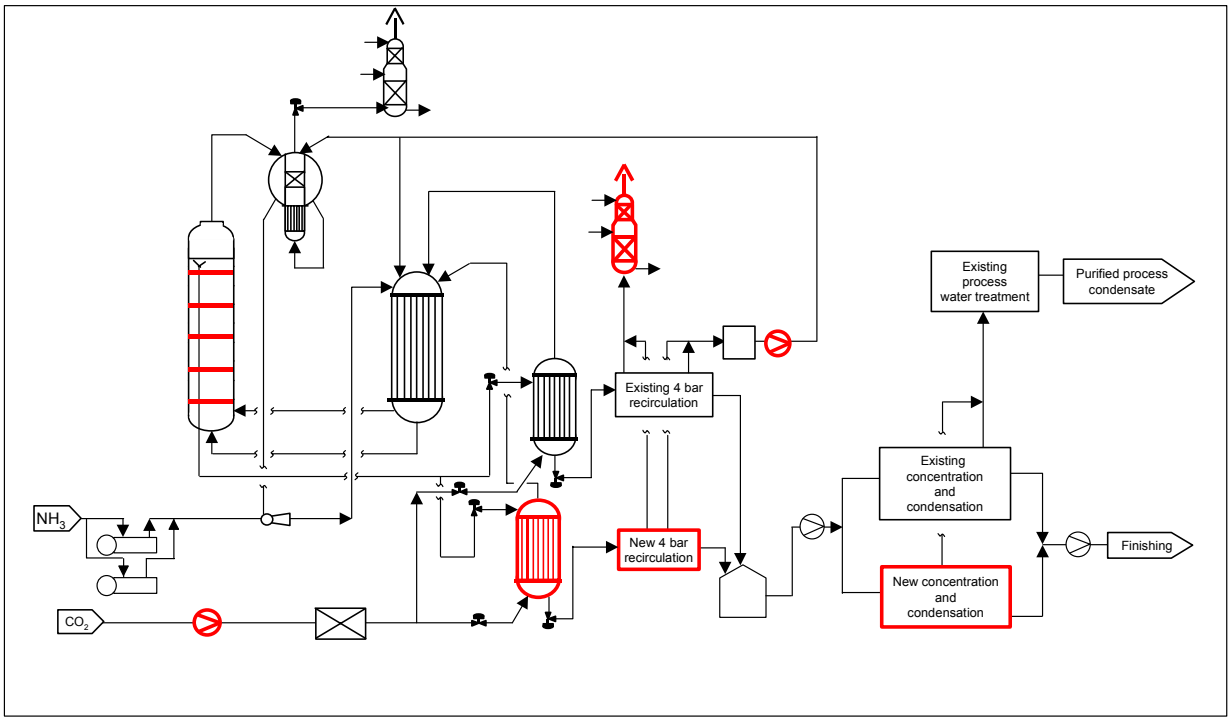
#### Principles of the Double Stripper Debottlenecking Technology

In this technology a parallel-operated high-pressure stripper is added in the synthesis. The urea solution, leaving the urea reactor is partly sent to the existing stripper and partly sent to the new parallel-operated high-pressure stripper. The urea solutions leaving the strippers are each sent to a low-pressure recirculation section and the condensed carbamate streams are collected in one level tank and then sent back into the synthesis section.

The stripped vapours from both high-pressure strippers are condensed in one high-pressure carbamate condenser. Figure 3 provides a typical process scheme.

The capacity of the high-pressure carbamate condenser determines the plant capacity after the revamp. The steam consumption per ton of produced product is in the same order as the steam consumption in the original design.

**Figure 3: Typical process scheme of the Double Stripper Technology**




At Yuntianhua a pre-evaporator was installed instead of the shown parallel concentration and condensation section. The reason was that either prills or granules needed to be produced.

## 4.2 Petrochina Daqing

Around 2002 Petrochina Daqing also requested Stamicarbon, amongst others, to offer a technology to debottleneck the urea plant to a new design capacity of 2300 mtpd. Stamicarbon proposed here the Medium Pressure Add On Debottlenecking Technology, which was also under construction at Stamicarbon's parent company DSM. Petrochina Daqing decided to maintain the prill tower in operation.

Further the original high-pressure carbamate condenser was already replaced identically and a new one with about 10% more tubes already replaced the original stripper. Also at Petrochina Daqing the debottlenecking project had to be implemented in such a way that the necessary modifications could be implemented during a normal annual turn around.

## Principles of the Medium Pressure Add On Debottlenecking Technology

The urea solution leaving the urea reactor is partly sent to the existing high-pressure stripper and partly sent to a medium-pressure recirculation section. The medium-pressure recirculation section operates at a pressure of about 18 bars. In principle the existing high-pressure stripper is by-passed by this medium-pressure recirculation section. On top of this, condensation capacity is added in this recirculation section and thus the capacity increase by this revamp concept is independent from the capacity of the existing high-pressure carbamate condenser.

In this medium-pressure recirculation, the non-converted ammonia and carbon dioxide in the urea solution is separated from the urea solution in a medium-pressure dissociator by using 9 bar steam. The urea solution leaving this dissociator is sent to a medium-pressure carbon dioxide stripper in which this solution is stripped by some virgin carbon dioxide that is also needed to control the ammonia/carbon dioxide molar ratio in the medium-pressure carbamate condenser.

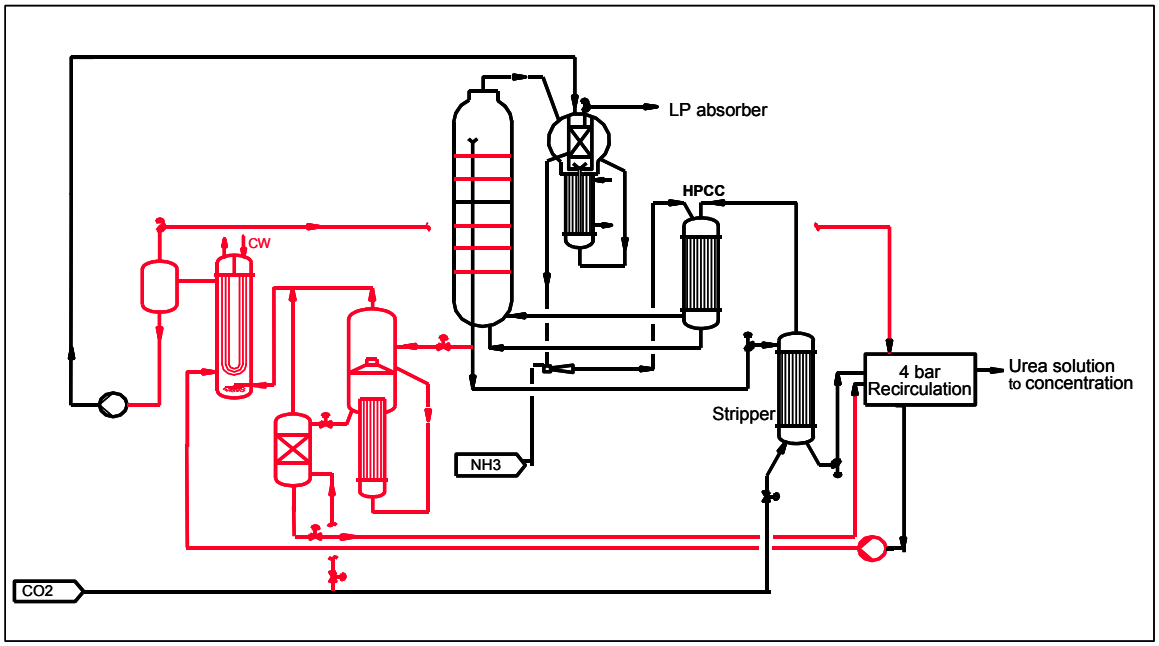
The dissociated ammonia and carbon dioxide leaving the dissociator and the carbon dioxide rich vapour leaving the carbon dioxide stripper together with the low-pressure carbamate from the existing low-pressure recirculation section, are introduced in a medium-pressure carbamate condenser in which the condensation of the vapour takes place.

The condensation heat is dissipated in a conditioned cooling water system or can be used for the greater part to concentrate the urea solution in the evaporation section.

To prevent crystallization of the carbamate, the water content is controlled at a content of about 20 wt%. The capacity of this medium-pressure recirculation section is determined by the amount of low-pressure carbamate containing about 30 wt% of water. In the medium-pressure recirculation section this carbamate is concentrated to 20 wt% water and thus determines the amount of urea solution going to this medium-pressure recirculation section. In this way the amount of water recycled to the synthesis by the carbamate is kept similar to the amount of recycled water before the revamp. Hence the chemical equilibrium is kept similar too and thus the steam consumption of the revamped urea plant will be in a same magnitude as the original.

The urea solution leaving this medium-pressure recirculation section is sent together with the urea solution, leaving the high pressure stripper, to the existing low-pressure recirculation section. Because of the large plant capacity increase, a parallel evaporation and urea finishing section is part of the debottlenecking or applying a pre-evaporator section increases the evaporation capacity. A process flow diagram is shown in Figure 4.

**Figure 4: Flow scheme Medium Pressure Add On Technology**




## Double Stripper versus Medium Pressure Add On

Why did Yuntianhua choose for the Double Stripper Debottlenecking Technology and Petrochina Daqing for the Medium Pressure Add On Debottlenecking Technology ?

In the year 2000 when Yuntianhua decided to debottleneck their urea plant the Double Stripper Debottlenecking Technology was fully proven and already successfully in operation at Saskferco in Canada since 1997. In this revamp project the urea plant was debottlenecked from 2000 mtpd to a design value of 2850 mtpd. In 2000 the plant was running at nearly 3000 mtpd. At that time the Medium Pressure Debottlenecking Technology as a revamp tool for a debottlenecking in a Stamicarbon plant was not yet in operation anywhere. The choice for the client therefore was clear.

In the year 2003 when Petrochina Daqing discussed the debottlenecking of their urea plant both proposed technologies were nearly fully proven, as also the Medium Pressure Add On system was on the point of starting up at Stamicarbon's parent, DSM's urea plant. Furthermore a somewhat bigger one already replaced the original stripper; the new parallel stripper would become very small. Also the original HPCC was replaced identically and would become a bottleneck at a plant capacity near the required new capacity. Enough reasons for the client to choose for the Medium Pressure Add On Debottlenecking Technology.

## 5. REVAMP CASE: PETROCHINA NINGXIA

Petrochina Ningxia operates two urea plants, one Stamicarbon $CO_2$ stripping plant with a nameplate capacity of 1740 mtpd, which started up in 1988.

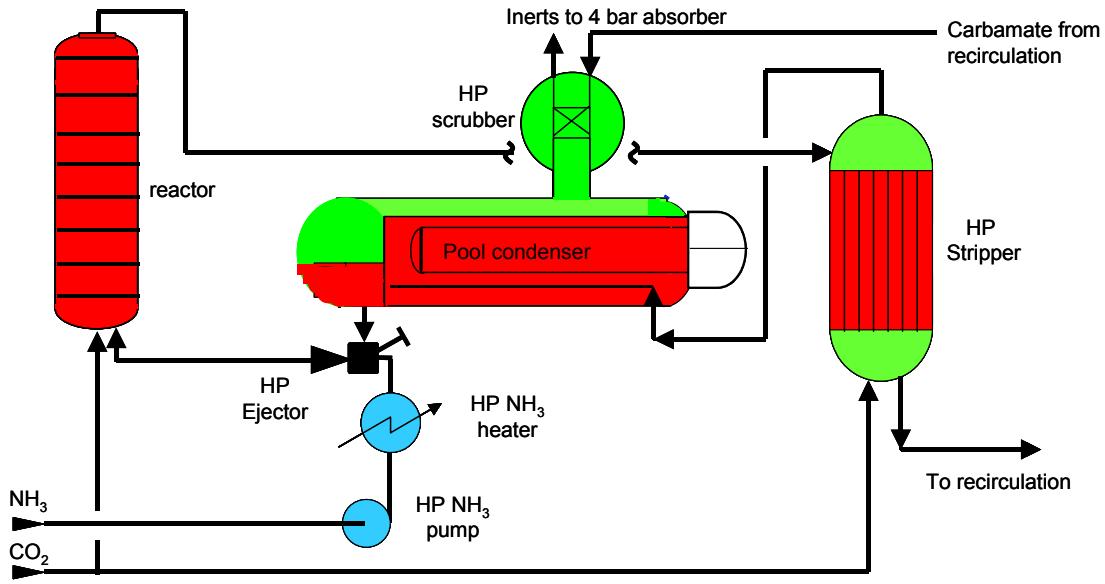
The second urea plant is an $NH_3$ stripping urea plant, relocated in 2000 from Mexico with a nameplate capacity of 1500 mtpd. After relocation the plant was upgraded with a new $NH_3$ stripper and a new high-pressure carbamate condenser. Actual plant capacity was near 1740 mtpd. The client requested to increase the capacity further by about 50%.

### Principles of the Pool condenser Debottlenecking Technology

By adding reactor volume and condensing capacity in the synthesis, urea plants of any kind can be debottlenecked to very large-scale capacities. In case a stripping plant is considered, this concept is integrated with a parallel-operated stripper as discussed in the double stripper concept. Conventional urea plants are revamped by using this concept to change the plant into a stripping unit.

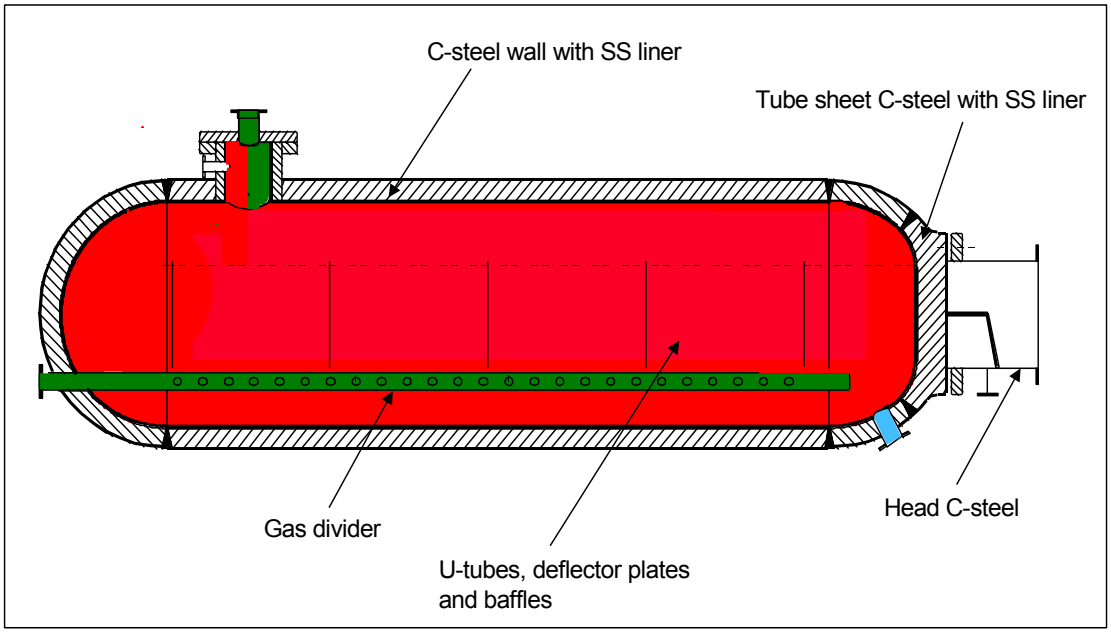
In this way the plant capacity is increased and the utility consumption is decreased drastically. In $NH_3$ stripping plants the $NH_3$ stripper is replaced by a $CO_2$ stripper. Figure 5 provides a typical flow scheme of the synthesis section after applying the Urea 2000*plus*™ Pool condenser Debottlenecking Technology in an $NH_3$ stripping urea plant.

**Figure 5: Flow scheme Pool condenser Debottlenecking Technology in $NH_3$ stripping urea plants.**



The Pool condenser is a horizontal high-pressure vessel in which reaction volume, condensing capacity and a scrubber are integrated. In principle the Pool condenser is a submerged condenser including reactor volume, which is needed to obtain sufficient retention time as can be seen in the following sketch.

**Figure 6: Pool condenser**




By means of the introduction of a Pool condenser and a $CO_2$ stripper the original Petrochina Ningxia $NH_3$ stripping urea plant with a plant capacity of 1740 mtpd is transformed into a modern Stamicarbon Pool condenser $CO_2$ stripping plant with a new design capacity of 2610 mtpd.

The existing medium and low-pressure recirculation sections will remain with some small modifications such as enlargements of some heaters and condensers.

The existing concentration section will be debottlenecked and upgraded in order to produce a 98 wt% urea melt suitable for the granulation unit.

The existing wastewater treatment will be debottlenecked also, in order to handle the 50% additional load.

## 6. CONCLUSIONS

- Debottlenecking projects improve your competitive advantage.
- The debottlenecking of a urea plant reduces the cost price of urea product.
- The investment costs per ton of product of a debottlenecking project are considerably lower than for a grass root plant.
- Stamicarbon is able to offer a custom made revamp scheme by implementing innovative but proven technologies leading to the most economic revamp scheme.
- Stamicarbon is able to introduce its innovative technologies in all kinds of urea plants

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