STAMICARBON HP STRIPPER FOR THERMAL STRIPPING PLANTS

STAMICARBON

NEXTCHEM
MAIRE Sustainable Technology Solutions

Conference name	Stamicarbon Symposium
Conference date	May 18-21, 2026

Author(s)	Stefano Cicchinelli and Nitesh Saidane
Classification	PUBLIC

TABLE OF CONTENTS

1 ABSTRACT

This paper presents the development and advantages of a Stamicarbon high-pressure stripper tailored for thermal stripping urea plants. Traditional titanium and bimetallic strippers used in these plants often suffer from severe corrosion, erosion, limited operational lifetime, and high replacement or maintenance costs. Building on extensive feedback from end-users and leveraging experience from multiple replacement projects worldwide, Stamicarbon designed a high-performance stripper using its proprietary E-type duplex stainless-steel grade. It provides a robust, efficient, and economically attractive solution for upgrading or replacing equipment in thermal stripping urea plants, significantly extending operational lifetime and improving plant performance. The paper compares process schemes, temperature profiles, and corrosion mechanisms of thermal versus CO_2-stripping technologies, highlighting how material limitations in existing units lead to premature failures.

2 INTRODUCTION

Stamicarbon, the nitrogen technology licensor of NEXTCHEM (MAIRE Group), has achieved a leadership position in urea technology and commitment to technological development, offering innovative solutions, reliability and dedication to customer support. This leadership position opens the opportunity to offer Stamicarbon's technology to customers operating urea plants based on other technologies, including thermal stripping plants.

Stamicarbon has a long track record in developing specialized stainless-steel grades to combat the corrosive environment in urea plants, establishing an industry standard. The latest innovation in this respect is the super duplex steel grade, nowadays branded as E-type and formerly known as Safurex® (see References 1 and 2).

The highest demand from a corrosion point of view is experienced in the high-pressure (HP) stripper. To address this, Stamicarbon developed an improved steel grade for heat exchanger tubes exposed to harsh corrosion conditions at elevated temperatures. This new material also offers improved corrosion resistance for HP strippers operating in thermal stripping urea plants. As a result, the specialty steel is an outstanding material choice for non-Stamicarbon thermal stripping plants, where even higher temperatures may prevail.

There are still many thermal stripping plants worldwide that suffer from severe corrosion and erosion in the heat exchanger tubes of HP strippers resulting in limited operational lifetime. Moreover, weld repairs in such HP strippers are challenging due to poor welding characteristics of certain materials, such as titanium. In many cases, HP strippers in thermal stripping plants need to be replaced before the expected lifetime of 20 years. In response to these challenges, an increasing number of end-users running thermal stripping plants have sought Stamicarbon's support.

3 FROM USER FEEDBACK TO PRODUCT INNOVATION

After extensive consultations with end-users of thermal stripping plants and in response to their growing interest in Stamicarbon's proprietary material solutions, Stamicarbon initiated a dedicated development program to design an HP stripper for application in thermal stripping processes. This initiative capitalizes on the proven operational performance of several HP strippers fabricated from Stamicarbon's proprietary steel grade, which have successfully replaced original equipment in existing thermal stripping units. Multiple design alternatives were systematically evaluated and reviewed with manufacturers to determine their feasibility with respect to fabrication and welding, identify and mitigate potential technical challenges, and conduct a comprehensive assessment of the overall weight and cost implications. This paper outlines the technical features, material upgrades, and innovative aspects of Stamicarbon's HP stripper designed for non-Stamicarbon thermal stripping plants.

4 DIFFERENTIATING PROCESS TECHNOLOGY

The main difference between a thermal stripper and Stamicarbon's CO_2 stripper lies in the process feed entering the stripper and the counter-current flow of strip gas in Stamicarbon's HP stripper. In Stamicarbon's HP stripper, the feed consists only of a liquid phase, whereas a thermal stripper operates with a gas-liquid mixture as its feed. In the Stamicarbon CO_2-stripping process, liquid/vapor (L/V) separation occurs at the top of the urea reactor, with liquid discharged via the downcomer to the HP stripper. In thermal stripping plants, L/V separation takes place in the top channel of the HP stripper. Figure 1a presents the standard process flow diagram for a thermal stripping urea plant: the multiphase stream from the reactor flows through the downcomer and enters the HP stripper at the top.

In the Stamicarbon CO_2-stripping process (Figure 1b), fresh carbon dioxide is supplied to the bottom of the HP stripper and flows counter-currently to the urea solution running as a film from top to bottom of heat exchanger tubes. Along this route, carbon dioxide acts as a stripping agent, enhancing the transfer of ammonia from the liquid phase into the gaseous phase. Due to unique vapor/liquid equilibria properties, stripping with carbon dioxide both recycles ammonia and reduces carbon dioxide content in the urea synthesis solution flowing down the heat exchanger tubes.

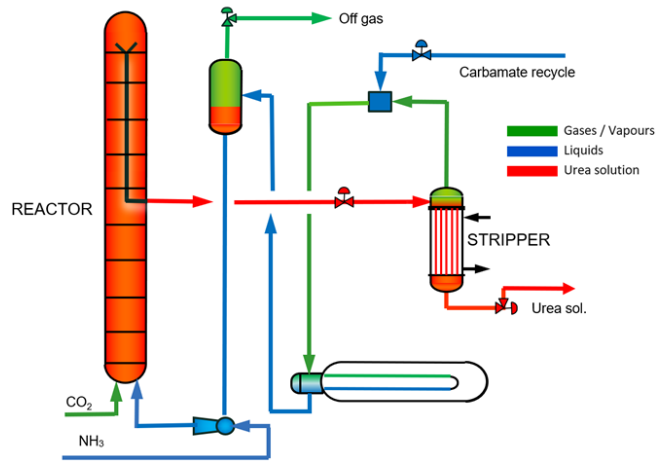

Figure 1a: Process scheme of thermal stripping technology.

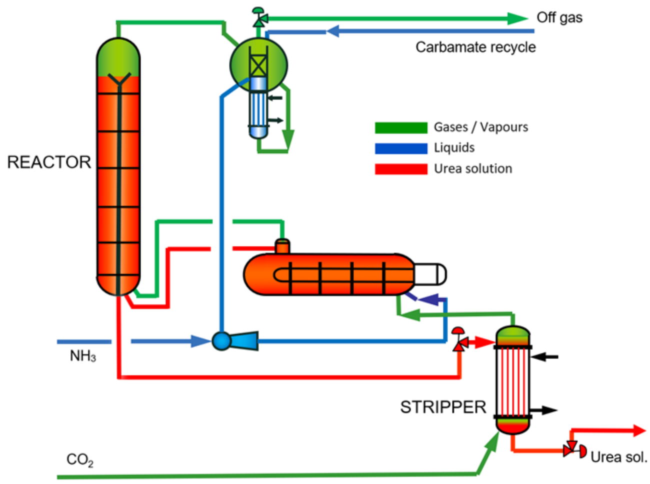

Figure 1b: Process scheme of Stamicarbon Pool Condenser technology.

5 TEMPERATURE PROFILE

The two process schemes produce distinct temperature profiles in the HP stripper heat exchanger tubes. Figure 2 illustrates the typical urea solution temperature profile along a CO_2-stripper.

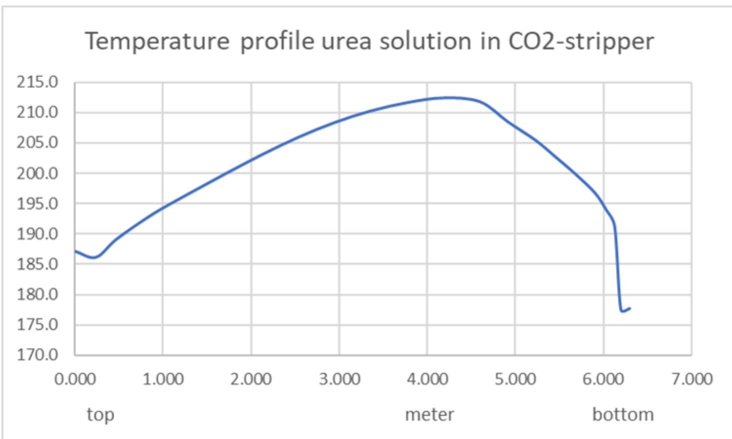

Figure 2: Temperature profile in CO_2 stripping technology.

The solution attains a maximum temperature of about 212 °C at approximately 4 m from the top of the tube. This peak temperature arises from the combined influence of several phenomena:

- Carbamate decomposition, which increases urea and water concentrations, thereby elevating the boiling point of the liquid film descending through the tubes;
- Heat transfer from HP steam on the shell side, which further raises the solution's temperature;
- The cooling effect of the cold CO_2 gas, typically entering at around 120 °C at the HP stripper bottom, which further reduces the fluid temperature in the bottom region, from 4-6 m of tube length;
- Evaporative cooling, occurring predominantly near the upper section of heat exchanger tubes.

Typically, the effective tube length for a CO_2 stripper is 6 m. The most significant cooling occurs at the bottom of the HP stripper, where the falling film exchanges heat with the cold CO_2.

The precise location of the maximum temperature within the HP stripper depends on the N/C and H/C ratios. Consequently, the highest corrosion rates occur at or near this temperature peak, typically around the mid-section of the heat exchanger tube in a CO_2 HP stripper.

By contrast, the temperature profile in a thermal stripper (see Figure 3) is markedly different and notably simpler, owing to the reduced number of active physical processes.

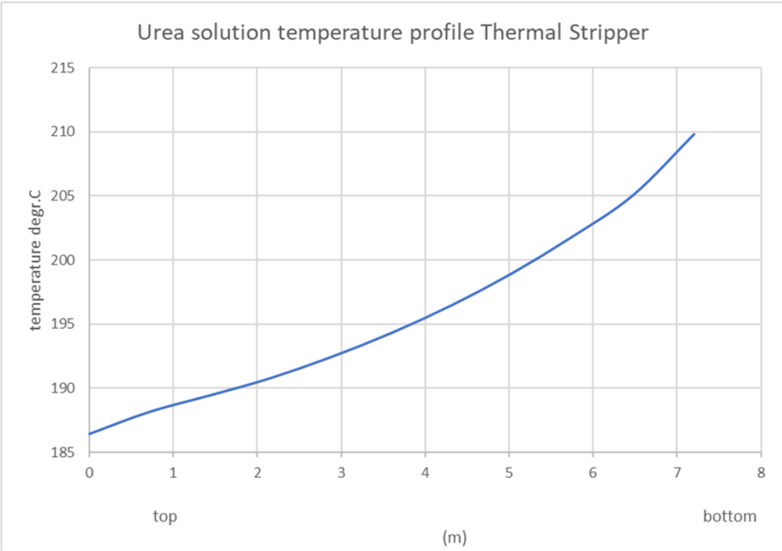

Figure 3: Temperature profile in thermal stripping technology.

Without a cooling agent, carbamate decomposition dictates the boiling point, causing progressive heating of the falling film and leading to the highest corrosion toward the HP stripper bottom in bimetallic strippers. Meanwhile, titanium strippers are prone to intense erosion corrosion of the upper heat exchanger tubes (see Figure 4).

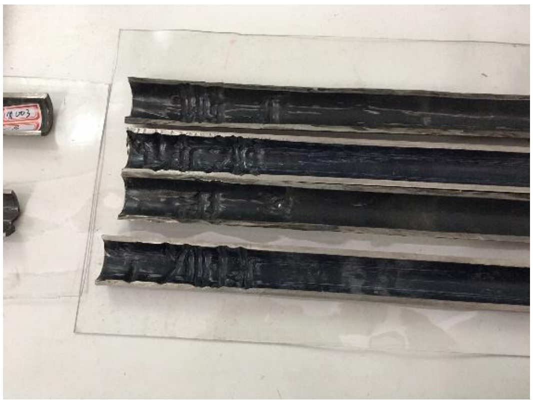

Figure 4: Severe erosion corrosion at the top of a titanium stripper. Left: tube end; right: cross section of titanium tubes.

6 MATERIAL OF CONSTRUCTION

The following table gives an impression of the installed base of strippers in thermal stripping plants, categorized by tube material in an HP stripper.

Tube material	Installed base	Status	Operating temperature, °C[1]
25-22-2 Cr/Ni/Mo	2	Out of production	204
Full zirconium	1	Out of production	210 or higher
OmegaBond	6	Out of production	210
Bimetallic[2]	>60	Standard	204
Titanium	>80	For replacement only	207

Table 1: Installed base of strippers.

The goal has always been to find a material resistant to corrosion at high temperatures, economically viable and suitable for long-term operation.

Bimetallic strippers have become the standard solution in thermal stripping plants, offering an alternative to titanium strippers despite limitations under certain process conditions. Converting a titanium stripper to a bimetallic one requires lowering the bottom temperature and adding passivation air to the stripper bottom. Because of the need for such modifications, titanium strippers are still often proposed to replace the existing titanium strippers. For a period, both titanium and bimetallic units were replaced by OmegaBond strippers. Although they provided superior erosion and corrosion resistance, their high material costs and limited manufacturing feasibility ultimately led to their withdrawal from the market.

In this context, Stamicarbon offers the optimum solution for replacing both titanium and bimetallic strippers through a tailor-made design of an HP stripper utilizing Stamicarbon's proprietary steel grade.

7 STAMICARBON EXPERIENCE: REPLACEMENT PROJECTS IN THERMAL STRIPPING PLANTS

The excellent performance of Stamicarbon's proprietary E-type steel grade in thermal stripping plants is well established and summarized in this chapter.

7.1 Argentina/Canada

In 2003, Argentina became home to the world's largest thermal stripping urea plant, designed by Snamprogetti with a capacity of 3250 MTPD. The synthesis section's bimetallic stripper exhibited significant corrosion and excessive tube leakages, ultimately compromising operational reliability and necessitating its withdrawal from service. Following Stamicarbon's recommendations, the plant owner opted to temporarily install a readily available E-type HP stripper, originally engineered for a Stamicarbon CO_2-stripping plant.

[1] *The temperatures cited are those measured in the bottom channel, which represent the maximum tube temperatures.*
2 *Unlike OmegaBond and titanium designs, bimetallic strippers employ a dedicated passivation air stream in the bottom channel to maintain a protective oxide layer on the 25-22-2 stainless-steel components, preventing their transition to active corrosion state.*

The E-type HP stripper operated successfully in Argentina for almost four years. No abnormal corrosion was observed, and the highest corrosion was observed in the bottom part of the heat exchanger tubes as expected. The corrosion rate was comparable to that of strippers in CO_2 stripping plants.

After four years, the HP stripper was relocated from Argentina to Canada and installed in a thermal stripping urea plant designed by Snamprogetti, also replacing an existing bimetallic stripper which reached end of life. Stamicarbon HP stripper operated successfully without major problems for more than 10 years. The corrosion rate of the E-type heat exchanger tubes increased somewhat since no passivation air was added, which was the case in Argentina. It should be noted that in both cases the liquid distribution system was not yet optimized, which also accounts for somewhat higher corrosion rates.

7.2 Russia

In another Snamprogetti urea plant with a nameplate capacity of 1000 MTPD, the original bimetallic stripper nearing the end of its service life was replaced by Stamicarbon's E-type HP stripper. Since the installation in 2012, the unit has operated flawlessly, with no operational problems or corrosion issues. In this case, the liquid distribution system at the top of the HP stripper was modified to ensure proper L/V separation. A central distributor was implemented (see Figure 5). The mixed solution from the reactor enters the perforated basket, where preliminary separation of liquid and gas phases occurs. The liquid is then distributed over the tube sheet by the basket geometry, which promotes flow from the center toward the periphery.

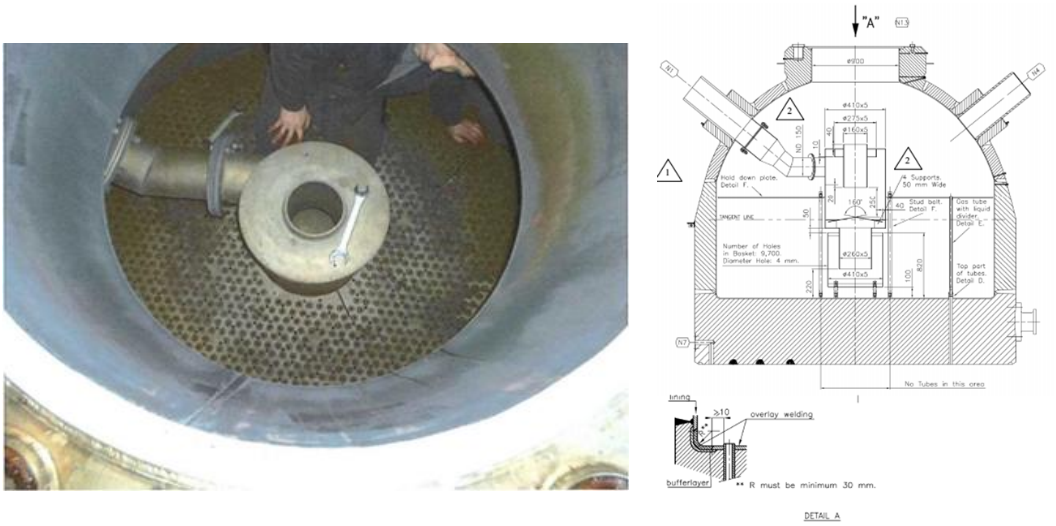

Figure 5: A central liquid inlet system (distributor) specially designed for this thermal stripper.

The L/V separator was designed with a tangential inlet, and the perforated basket was intended to ensure controlled liquid distribution across the tube sheet surface, minimizing accumulation zones and enhancing process stability. However, the client reported that the HP stripper efficiency was not optimal. Internal inspection confirmed that the liquid distribution system was not optimal, and improvements have been made.

8 THERMAL STRIPPER REPLACEMENT

When replacing an HP stripper, the primary objective is to minimize piping modifications. Furthermore, the weight of the replacement HP stripper should not exceed the original one. Snamprogetti strippers are typically installed at a height of about 3 m above ground level for easy removal of the radioactive source of the level gauge. Additionally, the bottom channel is considerably longer as it needs to match the length of the top channel to enable reversibility. Top and bottom channels have the same number of nozzles, some of which are blinded. When the HP stripper is reversed, the nozzles previously used in the lower channel are opened, while those in the upper channel are closed, and vice versa.

Tube lengths generally range from 5.5 m to, in some cases, 5 m, and in the earliest HP strippers even 4.5 m. For easier installation with minimal piping changes, the new HP stripper must maintain the position of the upper tube sheet at the same level as the previous one, while the lower tube sheet can be slightly lowered. This adjustment is possible because the bottom channel becomes smaller and there is no longer a need to remove the radioactive level gauge from below.

8.1 Replacement of Titanium Strippers

8.1.1 Design of Top Channel

As previously explained, in Snamprogetti technology a mixed-phase stream from the reactor enters the top of the HP stripper. This stream must undergo phase separation within the upper channel to ensure proper process stability and efficiency.

The most obvious choice is to propose a liquid distributor like the one used in the original HP stripper, which includes an initial distribution ring where the L/V separation occurs. Subsequently, the liquid overflows into the central area, where the gas risers are also located. The liquid is then distributed from the upper plate to the lower perforated plate, falling ultimately on the upper tube sheet.

The liquid distributors typical of Stamicarbon technology are replaced by ferrules (see Figure 6), which create liquid film inside the tubes. Gas risers are also included to allow the gas to rise from the tubes to the gas outlet nozzle. Although the ferrule length remains the same, the design follows Stamicarbon's optimized configuration to ensure proper coupling and prevent bypasses.

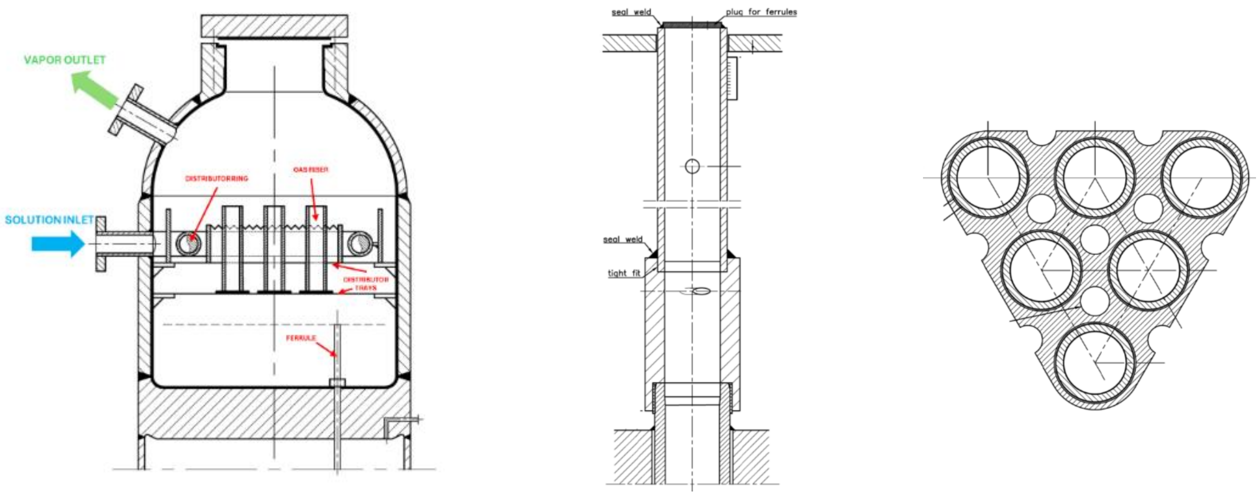

Figure 6: Left: optimized design top channel HP stripper; middle: ferrule; right: hold-down plate.

It is important to clarify the difference between the liquid dividers used in Stamicarbon technology and the so-called ferrules employed in Snamprogetti technology. In both cases, these components serve to distribute the liquid inside the stripper tubes, creating a uniform film that promotes heat transfer and separation. However, ferrules are much shorter than Stamicarbon's liquid dividers, primarily because the distribution system in the top channel is different.

In Stamicarbon technology, the vapors rising through the tubes and passing the liquid dividers are directed straight toward the outlet nozzle. In Snamprogetti technology, by contrast, the vapors exiting the tubes through the ferrules are routed via five gas risers into the upper section of the top channel, where they mix with vapors coming from the stripper before being discharged through the outlet. There is a grid above the ferrules that holds them firmly in position.

This hold-down grid has been redesigned in the form of hold-down "plate" configuration (as shown in Figure 6) to provide stability for the ferrules and easy assembly during maintenance. Finally, splash protection, which was previously required to protect the titanium lining, is no longer necessary. This solution represents the best possible option (refer to Figure 6).

8.1.2 Optimized Design Shell and Tubes

With respect to heat exchanger tubes, the most appropriate choice for the tube ID was to maintain the original dimension, reflecting (almost) the same number of tubes. Since the thickness of E-type tubes is lower than that of titanium, there is some flexibility in pitch dimensions. By keeping the original pitch, additional tubes can be accommodated while maintaining the same shell diameter.

A distinctive feature of many titanium strippers is that steam is introduced from the bottom while the condensate exits through the nozzle at the top of the shell. This arrangement was originally adopted to minimize erosion corrosion effects in the upper part of the tubes. Stamicarbon's preferred configuration, however, is to introduce steam from the top and discharge condensate from the bottom, as the risk of erosion corrosion no longer exists (see Figure 7). Nevertheless, the original nozzle location for steam condensate can be retained to accommodate existing piping arrangements, providing a customized solution for specific plant requirements.

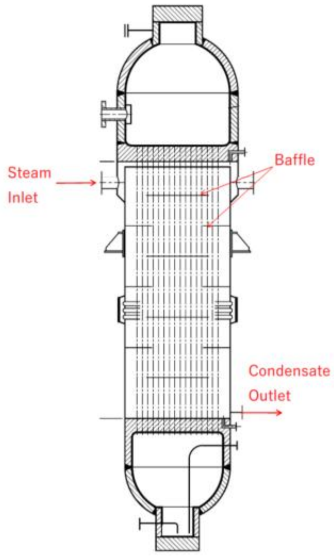

Figure 7: Optimized shell design.

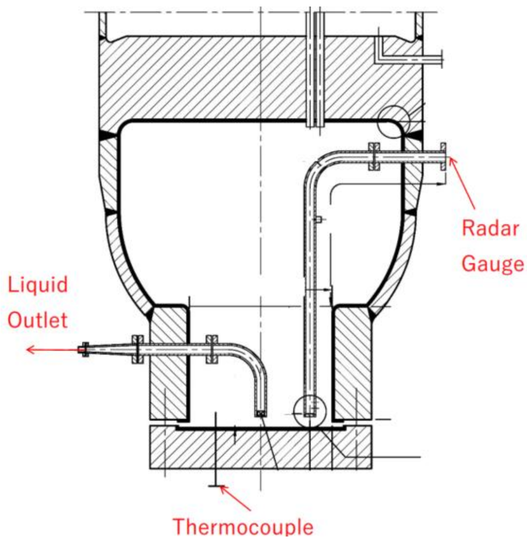

Figure 8: Optimized design bottom channel.

8.1.3 Optimized Design Bottom Channel

The design of the bottom channel has been completely revised and improved. It no longer needs to be identical to the top channel and is therefore significantly shorter. Additional nozzles sealed with blind flanges are no longer required, as the stripper no longer needs to be overturned. As shown in Figure 8, the radar level guide is inserted from the side, a feature typical of the Stamicarbon arrangement. Stamicarbon offers standard radar level measuring systems (see Figure 9), which has a major advantage for end-users, mainly for the following reasons:

- HSE compliance (zero radiation),
- Reduced maintenance costs,
- Greater reliability and accuracy,
- Easier calibration.

Figure 9: Radar level measurement system.

8.1.4 Weight Comparison

A titanium stripper is equipped with many duplicate components to allow it to be reversed by turning it upside down to extend its service life. These excess components increase the overall weight of the stripper. Even though titanium is lighter in weight, an E-type HP stripper with optimized design is lighter compared to a titanium stripper. Therefore, in replacement projects, an E-type HP stripper can be installed on the existing foundation even with an increased number of heat exchanger tubes.

Description	Stamicarbon design	Snamprogetti design
Fabricated weight (kg)	76600	79600

Table 2: Weight comparison of HP strippers for reference plant of 1760 MTPD capacity.

8.2 Replacement of Bimetallic Strippers

The previous section described replacing a titanium stripper with a Stamicarbon design. The same type of design is also suitable for replacing bimetallic strippers, with a few important considerations.

Bimetallic strippers consist of tubes made from a special stainless-steel alloy (Cr 25%, Ni 22%, Mo 2%) with an inner zirconium layer. This configuration provides good corrosion resistance under high-pressure and high-temperature conditions typical of urea synthesis.

However, the use of bimetallic strippers presents several operational challenges. They operate at a lower bottom temperature compared to titanium strippers (typically around 204 °C) and require dedicated passivation air supplied to the bottom channel by reciprocating compressors running continuously.

The proposed solution is to replace a bimetallic stripper with a Stamicarbon design, which eliminates the need for dedicated passivation air and allows operation at higher bottom temperatures (typically 207-208 °C) like in titanium strippers. Operating at these conditions reduces the corrosion rate, extending equipment lifetime beyond 20 years and improving process efficiency.

9 COST COMPARISON

While developing the optimized design, it was essential to ensure that the HP stripper does not only offer superior corrosion resistance and equal or better performance, but is also cost-competitive. The goal was to lower both the initial investment costs and total cost of ownership.

Titanium strippers are highly expensive due to the complex design requirements and high cost of materials. First, they require duplication of nozzles because the bottom channel must be identical to the top channel in terms of design and structural integrity. Second, the tubes and tube sheet require increased thickness to withstand operating conditions, which significantly raises material costs. Beyond the initial investment, maintenance costs are also considerable. Corrosion-related issues often lead to expensive interventions, including turnaround operations and tube plugging, which not only increase maintenance expenses but also reduce plant capacity and overall efficiency.

By contrast, Stamicarbon design provides a more economical solution while improving reliability and performance. It eliminates the need for duplicated nozzles and reduces material thickness requirements, resulting in a lower initial investment. Furthermore, its improved corrosion resistance minimizes the risk of unplanned shutdowns and capacity losses, thereby reducing long-term maintenance costs. These advantages translate into significantly lower total cost of ownership and improved life cycle value compared to titanium strippers.

Similar considerations apply to bimetallic strippers. First, there is no longer a need to install an additional air compressor or incur costs for their maintenance. Second, the return on investment is further improved thanks to reduced energy consumption and potential increase in plant capacity resulting from operating at a higher bottom temperature.

10 CONCLUSIONS

An HP stripper is the most critical component in the urea production process. It is designed to separate ammonia and carbon dioxide from the urea solution in the synthesis loop, received from the reactor.

Stamicarbon’s specially designed HP stripper technology offers several significant advantages over traditional titanium and bimetallic HP strippers for thermal stripping plants. The adoption of Stamicarbon’s proprietary E-type steel grade eliminates the need for reversibility, reduces oxygen passivation, fabrication weight, costs and lead time, while boosting durability and weld quality.

The improved connection between the tube and ferrules eliminates the possibility of bypassing, reducing corrosion problems. Furthermore, the optimized hold-down grid design provides efficient alignment of ferrules, while its simpler construction facilitates rapid assembly at site.

The Stamicarbon stripper requires fewer inspections and maintenance. It is less vulnerable to process upset conditions, which helps to increase the expected lifetime, lower the OPEX and improve the operability of the plant.

While respecting the specified size and weight restrictions, Stamicarbon can design a replacement HP stripper (notably for titanium stripper) with higher numbers of tubes to increase the heat exchange surface area by approximately 5%, thereby increasing plant capacity (revamping). By keeping the same internal tube diameter as in a titanium stripper, the tube load will be comparable or slightly lower, ensuring good flexibility with the possibility of running at higher capacity without the risk of flooding conditions.

In conclusion, the Stamicarbon HP stripper technology enhances the performance and reliability of the urea production process based on thermal stripping, offering a more efficient, cost-effective, and durable solution.

11 REFERENCES

1. A Specialty Safurex® for HP Stripper Tubes.
   Alex Scheerder, Kirk Ofei, Stamicarbon B.V., The Netherlands; Daniel Gulberg, Sandvik, Sweden.
   13th Stamicarbon UREA Symposium, May 9-12, 2016. Rotterdam, The Netherlands.

2. New Production Route for Safurex®: Hot Isostatic Pressing.
   Alex Scheerder, Kirk Ofei, Stamicarbon B.V., The Netherlands; Erik Solomonsson, Sandvik Powder Solutions, Sweden.
   13th Stamicarbon UREA Symposium, May 9-12, 2016. Rotterdam, The Netherlands.

Stamicarbon B.V.

REGISTERED OFFICE
Mercator 3, 6135 KW Sittard,
The Netherlands
P.O. Box 53 - 6160 AB Geleen
P +31 46 4237000
F +31 46 4237001

s.cicchinelli@nextchem.com
Proposal Manager

nitesh.saidane@stamicarbon.com
Mechanical Engineer

stamicarbon.com

STAMICARBON
NEXTCHEM Sustainable Technology Solutions

NEXTCHEM