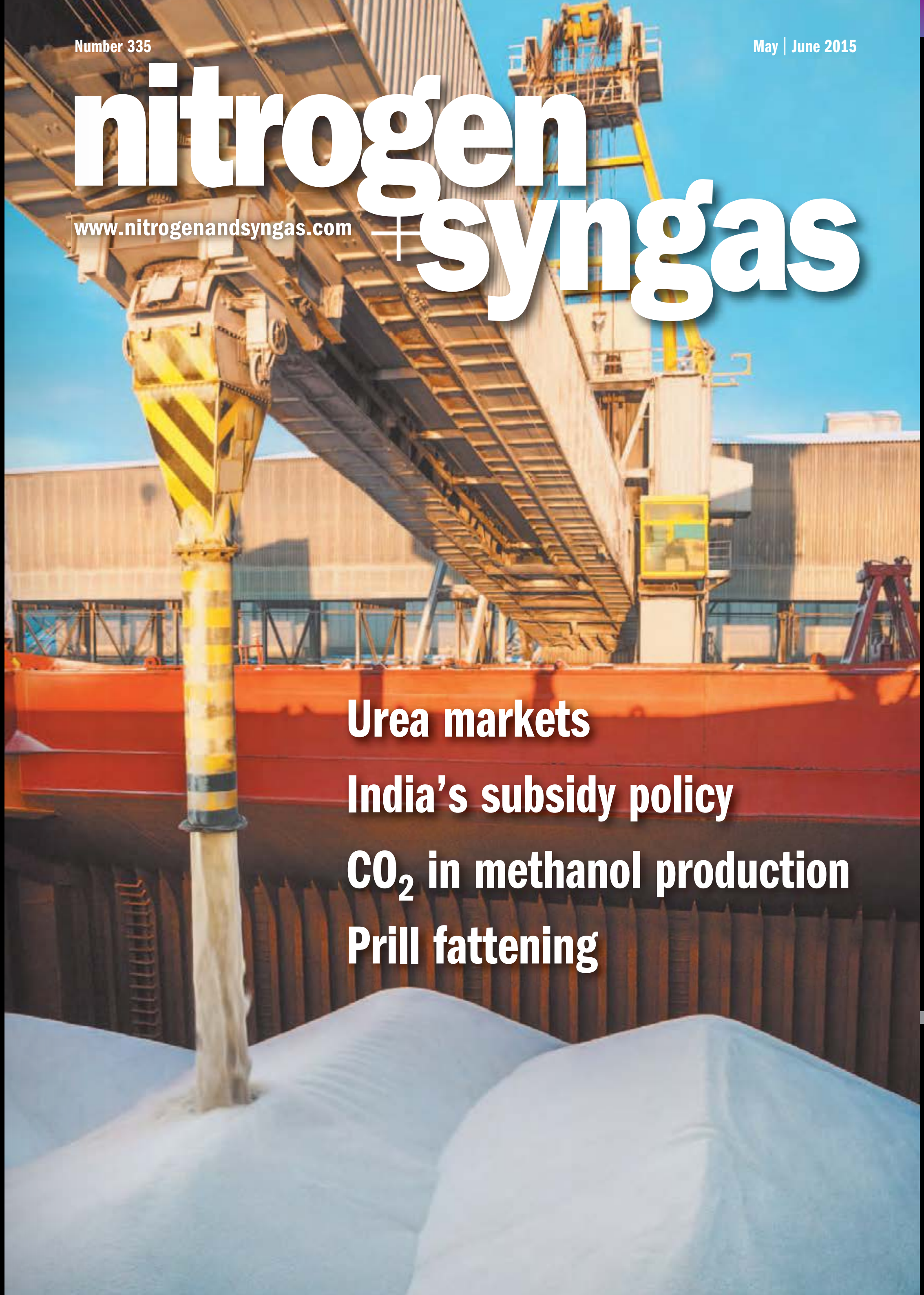
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Welcome to our interactive version of Nitrogen+Syngas Issue 335

Please use either the buttons on the left or top right of the page to navigate your way around this interactive PDF



CONTENTS
What's in issue 335

COVER FEATURE 1
Urea markets

COVER FEATURE 2
India's subsidy policy

COVER FEATURE 3
CO_2 in methanol production

COVER FEATURE 4
Prill fattening

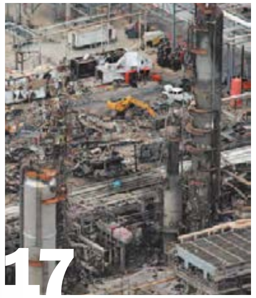
NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Cover: *Loading fertilizer into the hold of a ship.*
Pro-syanov/iStockphoto.com



17

Facility siting

Coexisting with residential development.

28

Prill fattening

Boosting fertilizer prill quality.

Read this issue online at: www.nitrogenandsyngas.com

Published by:
BCInsight

nitrogen+syngas
www.nitrogenandsyngas.com

NUMBER 335
MAY | JUNE 2015

CONTENTS

REGULARS

CONTENTS
What's in issue 335

COVER FEATURE 1
Urea markets

COVER FEATURE 2
India's subsidy policy

COVER FEATURE 3
CO_2 in methanol production

COVER FEATURE 4
Prill fattening

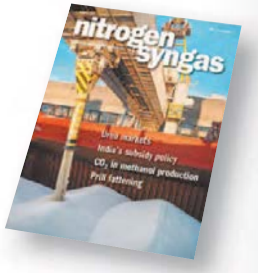
NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

The rise and rise of methanol



> There are some of the first signs that the methanol revolution may be spreading to the US.

Synthesis gas is an extremely versatile mix of molecules, with all manner of uses. Many of these depend on the hydrogen that is liberated in a partial oxidation reaction, either used directly, in refineries and now even vehicles, or via a Haber-Bosch reaction to produce ammonia. Indeed, ammonia continues to be far and away the largest use for syngas, with over 170 million tonnes produced every year, most of it destined for agriculture as fertilizer, on its own or via downstream uses like urea and ammonium nitrate. Ammonia remains the world's second largest industrial chemical by tonnage, behind only sulphuric acid.

By contrast, the other major syngas derivative, methanol, has been for many years somewhat in the shadow of ammonia, its uses confined to various industrial chemicals such as formaldehyde and acetic acid for fibre and resin production. But recently methanol has been seeing something of a seismic change in its fortunes, as it makes its way first into energy and fuel markets, and now into petrochemicals. Davy Process Technology predicted, back in the 1990s, that the new wave of large-scale methanol plants would bring the cost of methanol synthesis down to the level where it could compete in these new markets, and that this would lead to a step-change in production. I confess to having been slightly sceptical at the time, but their prediction has proved to be completely true, and the reason has been – like so many things in the past decade – down to China.

China's enthusiastic embrace of coal-derived methanol as a supplementary fuel – in vehicles (via methanol fuel blending) and in homes (via LPG blending of its derivative dimethyl ether – DME) has led to a big upsurge of demand there, but even this now looks set to be dwarfed by the move towards ethylene and propylene production via so-called methanol to olefins or MTO technology. Several papers at the recent Asia Petrochemical Industry Conference (APIC) in Seoul touched on this, with Mark Berggren of Methanol Market Services Asia (MMSA) saying that Chinese methanol demand has risen from 20 million t/a in 2010 to 50 million t/a in 2015, and is se to rise to 80 million t/a by 2020, out of total global demand of 117 million t/a. TecnonOrbiChem put the 2020 figure at 100 million t/a, with Chinese demand representing 65-70 million t/a of this, and the MTO sector 45 million t/a of that.

Although the figures show considerable variability, based on the timing of the plethora of new Chinese MTO projects, the direction is unmistakeable.

Indeed, so great is this new drive for MTO production in China that it is starting to impact on possible methanol production in the US, with some capacity now under development on the west coast of North America built purely to supply the Chinese market, as a surprising number of new Chinese MTO plants are not built with integrated/captive methanol production but instead intend to work off the merchant market. This so-called 'methanol bridge' was contemplated once before, when the port of Rotterdam in northwest Europe considered an MTO plant a decade or more ago fed by cheap methanol from South America, but now it seems to be a genuine possibility, if the Chinese developers of these methanol projects are prepared to commit the financing. And there are some of the first signs that the methanol revolution may be spreading to the US via methanol to gasoline (MTG) production, using methanol as a way of converting cheap shale gas into vehicle fuel. Both ZeoGas and more recently Methanol Holdings Trinidad Ltd are currently working on MTG plants on the US Gulf Coast, and there are at least a dozen methanol facilities under development across the country.

With methanol being trialled as a clean shipping fuel and methanol blending in gasoline spreading to countries like Israel, Australia and some EU states, the future looks bright for methanol. ■

Richard Hands, Editor

CONTENTS
What's in issue 335

COVER FEATURE 1
Urea markets

COVER FEATURE 2
India's subsidy policy

COVER FEATURE 3
CO_2 in methanol production

COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Price trends

MARKET INSIGHT

Laura Cross, Senior Analyst, Integer Research, assesses price trends and the market outlook for nitrogen.

NITROGEN

The global nitrogen market faced a great deal of uncertainty in the opening months of 2015. How low would prices go? When would the seemingly unending stream of Chinese urea exports ease? What would be the impact of the rapid decline in oil prices? These questions and more led to buyers choosing to stall their purchase decisions in the hope that prices would fall further. Indeed they were ultimately rewarded with an almost uninterrupted decrease in nitrogen prices between January and April in the face of substantial global oversupply.

The notion of a global nitrogen oversupply, particularly of urea, is nothing new given that the market is currently in a supply-driven phase, kick-started by the influx of new capacity in the market since 2012. But the timing and severity in which the situation came to a head in Q1 2015 was certainly not in line with earlier expectations.

Slow demand also played a part in falling nitrogen prices, but the origins of the recent market phase are predominantly supply-driven. The extent of the oversupply in the market is reflected most notably in the urea market, where recent prices have fallen up to US$15 per tonne below the market floor.

By studying the key fundamentals and monitoring the cash costs of nitrogen production at the industry margin, Integer concludes that the recent market floor price is around US$270-280/t for urea. The fact that the Black Sea urea price fell to US$255/t in April reinforces the weak state of the market, but it is important to note that prices sustained at this level are not backed up by current nitrogen production economics. Our floor price analysis remains the same, but the market has been in a state of flux and it is not unusual for prices to temporarily fall below the floor even though the fundamentals point to a higher floor price.

China has been a major contributor to the ramp up in global nitrogen supply, and exports out of the country have added to the downward pressure on urea prices. The Chinese government heavily incentivised nitrogen capacity growth in the 2000s as part of its central policy to ensure food self-sufficiency, a strategy that many other countries have employed to support domestic agriculture through improved access to fertilizers, particularly nitrogen. However, investment in Chinese nitrogen capacity has since exceeded domestic requirements as per the government's original intentions, and it is this excess capacity that has led to the rise in Chinese exports. For 2015, the prohibitive seasonal urea export tariff that was implemented to deter producers from exporting at the expense of domestic supply has been replaced by a flat, year-round tax, and the result has been both immediate and dramatic. Between January and March 2015, Chinese urea exports totalled 4.4 million tonnes, more than double the 2 million tonnes that were exported in the same period in 2014.

The second factor that has allowed China to establish a firm hold on the global nitrogen market is the country's rapidly changing coal market. Integer estimates that 51% of upstream ammonia feedstock in China uses anthracite coal, with a further 18% of capacity using other coal grades. The result is that changes in coal pricing have a major impact on nitrogen production costs. In an uncanny resemblance to the nitrogen market, the Chinese coal market has undergone a sustained period of oversupply, leading to prices steadily falling from around US$10/MMBtu in 2012 to just US$5.50/MMBtu in late 2014. Coal prices were more stable at around US$5.60/MMBtu in Q1 2015, suggesting that the coal market is close to its floor, but nevertheless Chinese nitrogen remains far less expensive to export than it was three years ago.

So what are the prospects for the nitrogen market, and the role of China, in light of the recent sharp decline in oil prices? One might link the current state of the nitrogen market to the recent fall in oil prices, but as discussed above, we know that the recent fall in nitrogen prices is a direct result of market oversupply, primarily driven by the impact of China. Furthermore, the marginal cost of nitrogen production in China tracks coal prices, which have become decoupled from the oil market in the short term. Over the longer term nitrogen prices have historically correlated well with oil prices, and while oil is very rarely used to make nitrogen, it is indicative of energy prices in general, and the oil price has historically been a leading influence on nitrogen feedstock costs. Analyst consensus forecasts for the next five years point towards a recovery in oil prices, a view which Integer shares having analysed the crude oil production cost curve – which shows that a significant amount of oil supply operates at above current price levels. We would expect to see some reversion to trend in oil prices and if this takes place soon enough, it is likely to limit and moderate the effect on gas and coal prices, and therefore nitrogen prices. ■

Table 1: **Price indications**

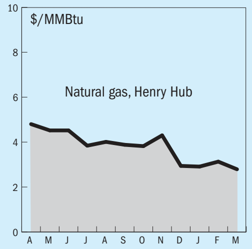
Cash equivalent	**mid-Mar**	**mid-Jan**	**mid-Nov**	**mid-Sept**
Ammonia ($/t)				
f.o.b. Caribbean	435	440-505	615	530
f.o.b. Arab Gulf	400-430	470-490	635	583-600
c.fr N.W. Europe	473-510	480-535	650-710	570-620
c.fr India	490-500	530-570	555-630	550-570
Urea ($/t)				
f.o.b. bulk Black Sea	270-280	320-325	315-318	318-325
f.o.b. bulk Arab Gulf*	270-275	320-325	307-320	335-360
f.o.b. bulk Caribbean (granular)	290-300	325-335	340-350	350-355
f.o.b. bagged China	275-283	280-285	289-294	285-290
DAP ($/t)				
f.o.b. bulk US Gulf	485	485	460	480
UAN (€/tonne)				
f.o.t. ex-tank Rouen, 30%N	231-235	200-227	200-203	194-198

Notes:
n.a. price not available at time of going to press
n.m. no market
** high-end granular*

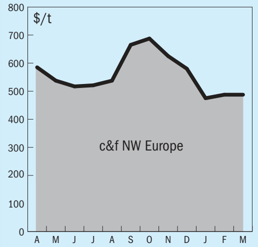
Source: Fertilizer Week

END OF MONTH SPOT PRICES

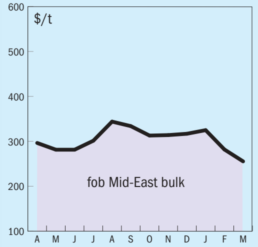
natural gas



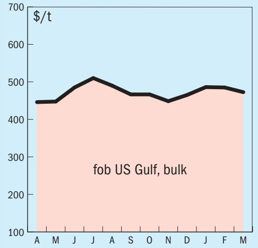
ammonia

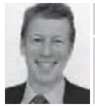


urea



diammonium phosphate





MARKET INSIGHT

Mike Nash, Global Business Director, IHS Chemical, assesses the market for methanol.

METHANOL

In North America, the April contract gas reference price was settled at $2.63/MMBtu for Texas, and $2.69/MMBtu for Louisiana, down $0.29 from March. The market has been fairly quiet with prices softening on the back of improved supply as operating rates improved in Trinidad and Venezuela.

Production in Canada continues to be constrained by a mechanical issue; Methanex will have a major 60-day overhaul this summer to resolve it. Venezuela had suffered production loses stemming from what was heard to be a feedstock disruption, while Methanex's Chilean unit is estimated to be operating around 35% of nameplate on a tolling arrangement. Operations are expected to be further curtailed or suspended as the southern hemisphere passes into winter and gas demand for heating supersedes industrial needs. In Trinidad, gas limitations spiked in mid-April and operating rates for all units dropped down to 69% at best. Another large curtailment may occur in 2H 2015.

In Europe the market remains thinly traded and momentum was fairly slow. The spread between European and North American spot prices narrowed considerably. Units in Egypt and the Black Sea region remain closed. Iranian production operated normally, and Sirte in Libya still has one line running. EMethanex in Damietta, Egypt, is closed due to gas constraints. The facility is expected to restart in mid-May, but its absence has supported European markets. Prices are likely to remain supported at least for as long as these outages continue, although the largely stable demand profile in Europe is also supportive. Methanol demand into formaldehyde remains stable and demand into acetic acid has been healthy. BP's maintenance at its acetic acid unit will reduce production but despite this, inventories in Northwest Europe are good. The reduced methanol demand into acetic acid at BP's unit will take some pressure away from European supply as a whole, counteracting some of the tightness in the Mediterranean market. Reduced operating rates at vinyl acetate units in North America are likely to free up acetic acid availability in the Atlantic Basin for May and June. A freight rail strike in Germany is not thought to have significantly impacted methanol deliveries to customers in the region. A deal for May was concluded at €321/t f.o.b. T2 Rotterdam, with offers rising to €324/t.

The Asian market sentiment is low, driven by the weak Chinese market. Chinese market momentum has been sluggish with a slight price decline on both domestic and import material. The spot market was quiet with a large gap between buyers and sellers. MTO producers remained on the sidelines rather than buying spot. A new 900,000 t/a (in terms of methanol consumption) MTO plant in Shandong province is still looking for a good time to come on stream. Domestic production is stable with an average operating rate of 51% of capacity. Coastal inventory improved since there were limited actual product transactions. With respect to seasonal factors driven consumption, formaldehyde demand is stable-to-strong. The DME sector remains weak, with a limited price spread between DME and LPG.

In Korea, the market is running well with adequate supply by term contract. Korean market activity was subdued by the unclear market trend in the China market this week, with little business being done. Demand into key derivatives is very stable. In Taiwan, the market is stable. Demand into formaldehyde picked up with the major units resuming operation. No spot deals have been heard this week.

In Southeast Asia, supply is moderately tight with a major plant outage and two other major plants operating at low rates. Demand into acetic acid slowed down with a major unit having started a month long turnaround. The Brunei Methanol Co unit is supposed to restart by the end of May. Petronas's two units are running at relatively low (60-80%) rates, it is understood.

In Taiwan, the market is running well with adequate contract supply. Spot market sentiment is quiet. Market players are not urgently seeking to conclude deals until they have better understood the China market trend. Demand into acetic acid has improved after the restart of the major acetic acid unit.

The Chinese government plans to step up clean-coal use in the next few years, with the National Energy Administration (NEA) issuing a general plan for 2015-20. ■

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

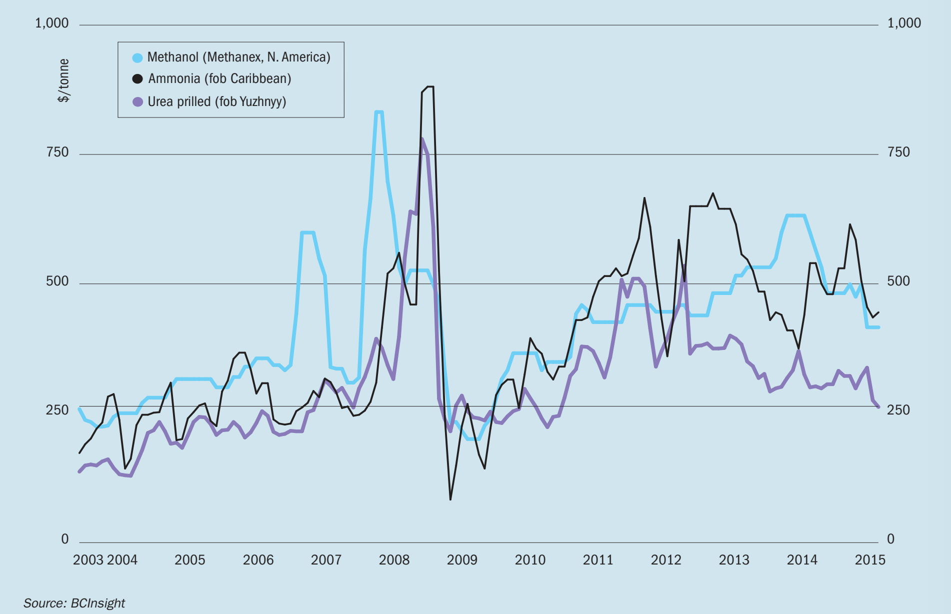
BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Market outlook

Historical price trends $/tonne



Source: BCInsight

AMMONIA

- After ending 2014 on a five-month bull run, ammonia prices slipped back into alignment with urea in the opening months of 2015.
- The Yuzhnyy ammonia price remained around US$400/tonne FOB between January and April 2015, following a rapid correction of almost US$200/tonne in late 2014.
- Demand from the US is expected to increase significantly in the next few months as the planting season finally gets underway following a sustained period of unfavourable weather.
- Although global supply is sufficient to meet current demand, local energy restrictions and issues have led to regional imbalances.
- In particular, concerns about the visibility of the long-term supply of Russian gas to Ukraine, gas curtailments in Trinidad and domestic gas shortages in Egypt have threatened export availability out of these regions, and seem set to continue to do so.

UREA

- In Q1 2015 the urea market suffered its weakest period of pricing since 2010, driven by substantial global oversupply – this was far more pronounced than in the ammonia market.
- The average March price was US$268/tonne FOB Yuzhny, and prices had fallen as low as US$255/tonne FOB at press time.
- A chronic global oversupply, especially in China, is to blame for the extremely weak sentiment, although the outlook is much improved, with many believing that urea prices have found their floor at current levels.
- Chinese prices have remained firm in recent months despite previous expectations, due to better netbacks for producers in the domestic market.
- Indian tenders have begun to appear and are expected to support global prices based on a targeted requirement of 1 million tonnes of urea imports ahead of the country's Kharif application season.

METHANOL

- Gas curtailments continue to affect production around the world. Trinidad in particular may see a significant reduction in natural gas availability during the second half of 2015.
- Egypt, Venezuela and Methanex's remaining Chilean unit also still face ongoing gas supply restrictions.
- These outages have covered for the underlying weakness in the market, helping to support prices in major markets.
- Methanex's first plant has now started up at Geismar and capacity continues to ramp up at OCI Beaumont, putting more supply into the US.
- Conversely there are signs that demand may be picking up in China in the second half of 2015.
- Falling global oil prices have helped exert downward pressure on methanol prices over the past year, and the pick-up in oil prices recently may help expectations of higher prices to follow later in the year.

CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Nitrogen Industry News

GERMANY

Haldor Topsoe and Ferrostaal to form joint venture

Industrial plant and project developer Ferrostaal GmbH has joined with Denmark-based catalyst and process technology company Haldor Topsoe A/S to establish Ferrostaal Topsoe Projects GmbH, a new 50-50 joint venture, to be based in Essen. The new company aims to position itself as a leading player in developing, financing and realising major industrial projects in the petrochemical, refining and environmental sectors. Fast-growing emerging economies around the world will be the primary market focus, but North America is also expected to hold business potential for the new company. The joint venture is subject to the usual approvals from regulatory authorities.

The two companies have already worked on a number of major projects together, most recently on two major ammonia-related projects in Tanzania and Cameroon. In Tanzania the companies are involved in the development of a large-scale ammonia complex together with the state-owned Tanzania Petroleum Development Corporation. This project is currently the largest investment project in the country with an investment volume of more than $1 billion.

Dr. Klaus Lesker, Managing Director of Ferrostaal GmbH, said; "Ferrostaal Topsoe Projects is a perfect match of competences, combining the world-leading technology portfolio of Haldor Topsoe with our ability to drive project development and facilitate investments translates into a highly attractive value proposition for customers. Moreover, in emerging economies our projects will leave a very positive footprint by enabling entire countries to utilize natural resources – natural gas or coal for example – to produce fertilizer or other valuable commodities, and in the process stimulate job creation and boost sustainable economic growth."

Haldor Topsoe's CEO Bjerne S. Clausen added that: "building partnerships to 'fast track' our way into new business areas or expand our current market-reach is a key part of our growth strategy. In this context the new joint venture is a huge step forward due to the positive synergies it carries. We also expect the joint venture to create opportunities within operations and maintenance of plants, a key business area that we are currently also looking to expand."

RUSSIA

EuroChem signs MoU to build five new urea plants

Russian fertilizer producer EuroChem has signed a memorandum of understanding with Maire Tecnimont and Italian credit export agency SACE for the construction of five ammonia-urea plants in Russia, the US and Kazakhstan over the next 10 years. Tecnimont will be invited to submit proposals for the engineering, procurement and construction of the plants, while SACE will look at issuing credit insurance policies for the projects. In Russia, the MoU covers the construction of an ammonia-urea facility in Nevinnomyssk with a capacity of 2,700 t/d of ammonia and 3,500 t/d of urea, and an ammonia plant in Kingisepp with a further 2,700 t/d of ammonia, which would also include an additional project to integrate urea production. Tecnimont says that it has already completed front-end engineering design (FEED) for both plants.

Under the agreement, the companies will also co-operate on two other ammonia-urea projects: one in Louisiana, USA, and the other near Zhanatas in Kazakhstan. However, the $1.5 billion Louisiana plant appears to have already fallen by the wayside, as EuroChem recently said that it has shelved plans to build a plant there due to US sanctions limiting access to funds and the drop in the rouble making projects in Russia more attractive. CFO Andrey Ilyin said: "the decision on the project is delayed due to changes on the financial markets, namely affected access to credit resources." EuroChem announced the Louisiana plant in 2013, and has already purchased 2,150 acres of land at Point Clair.

EuroChem is also involved in a $1 billion project to build an ammonia plant in Russia's Leningrad region near St Petersburg. The 46% decline in the value of the rouble due to sanctions over Ukraine has made Russian gas prices extremely cheap by international standards, according to EuroChem.

DENMARK

Topsoe reports increased profits

Haldor Topsoe's annual report for 2014 shows that the company's total revenue increased by 6% as compared to 2013 to a total of 5.69 billion krone with an operating profit (EBIT) of 563 million krone, in spite of a 151 million krone charge related to the closure of the subsidiary Haldor Topsoe Fuel Cell A/S. Adjusting for this item and a warranty provision change in 2013, EBIT increased by 118 million krone or 20% compared to 2013. The company says that the closure of Topsoe Fuel Cell is also set to increase the free cash flow from 2015 onwards, freeing capital for use in other investments and projects.

Revenue from the company's catalyst operations increased by 13% compared to 2013, driven by strong demand for the company's refining catalysts as well as other areas, but this was offset by a decrease in technology revenue by 10% compared to 2013, which is largely made up of engineering services, equipment and licensing.

In 2014 Topsoe completed two large expansions of its production sites in Frederikssund, Denmark and Houston, Texas and moved ahead with a new automotive catalyst plant in Tianjin, China. A key part of the company's growth strategy is to 'fast-track' its way into new business areas by partnering with relevant companies. During 2014, Topsoe established a new partnership with FLSmidth aimed at commercializing a promising and unique catalytic filter bag technology, and the joint venture above, with Ferrostaal, is another example of this.

UNITED STATES

Verdegris completes turnaround

Terra Nitrogen says that it has completed its planned turnaround at one of the company's ammonia and UAN plants – representing approximately half of the production capacity ITC Franklin Gothi at its Verdigris nitrogen complex in Oklahoma. The turnaround of the ammonia plant took approximately nine weeks, and the turnaround of the UAN plant took approximately eleven weeks. Work included upgrade projects to improve the production capacity and efficiency of the units.

Alaskan gas bill passes state House of Representatives

The Alaska House of Representatives has approved a bill to incentivise natural gas and fertilizer production in the state, in an effort to help restart Agrium's ammonia-urea facility at Kenai. The bill allows a company that produces urea, ammonia or gas-to-liquids products to credit their taxes if their feedstock comes from a state lease, and could be worth $3 million to Agrium, although the state royalties on gas use would in return generate $18 million in revenues should the plant return to full operation. The credit cannot be carried forward from year to year and its value cannot exceed the amount the state receives for its royalty share and would last until 2024. The bill must now clear the state Senate to become law.

Christy and Blasch sign exclusive supply agreement

Blasch Precision Ceramics, Inc., says that it has entered into an agreement with Christy Catalytics, appointing Christy as the exclusive worldwide distributor of their 99% Alumina ceramic precast boiler ferrules for the syngas industry. Jack Parrish, Blasch President and COO said: "we are very pleased to expand our global presence through this agreement with Christy. Our customers will now have global access not only to our ceramic ferrules, but to "boots-on-the-ground", technical personnel with years of experience in their market." Vernon Christensen, Vice President of Sales at Christy Catalytics, LLC said: "this agreement is a natural fit, and will nicely complement and round out our product offering, allowing us to bring additional innovative products to the market. We are excited to offer an enhanced product line to benefit our customers in the synthesis gas market."

Dyno Nobel to close AN production at Donora

Dyno Nobel says that it will idle its Donora ammonium nitrate manufacturing facility in Pennsylvania from May 1st due to a decline in demand caused by the contraction in mining of Appalachian coal as the US switches to cheaper shale gas for power generation. The plant employs 42 people and will be left on care and maintenance. Orders will be fulfilled from the 10,500 metric tonnes of ammonium nitrate still in storage at the site. Most of the staff will be laid off while the company evaluates whether the market will warrant the resumption of production at the plant in future, and Dyno Nobel said it did not rule out a sale to another company.

Derailment leads to AN spill

About 30 people were evacuated within a 1.5 mile radius of a train carrying ammonium nitrate in Trenton, South Carolina. Only one of the 39 rail cars was reportedly carrying ammonium nitrate, which spilled after the derailment, while another was reportedly carrying anhydrous ammonia but did not spill. The derailment, which affected 15 of the carriages, was reportedly due to a tree falling across the tracks.

Officials said there was no danger to the public at the time.

Ammonia plant nears completion

Dyno Nobel says that its new $850 million ammonia plant at Waggaman is now 75% complete. Ground was broken in August 2013 on the 800,000 t/a plant, sited within the Cornerstone Chemical Co's 800-acre complex on the Mississippi River, and the plant is scheduled to begin commercial operation in 2016. Dyno Nobel plans to use the ammonia to make ammonium nitrate for the explosives industry at its plants elsewhere in the US, company officials have said. The company is the largest supplier of explosives and related services in North America. The project is the first new ammonia plant built in the Louisiana in over 25 years and has been made possible by the US shale gas boom.

INDIA

Casale to build melamine plant

Casale has been awarded a contract by Gujarat State Fertilizer Co (GSFC) to build a 40,000 t/a melamine plant at the company's site in Vadodara, India. This is the first project that Casale will execute after the acquisition of the melamine technology portfolio from Borealis in 2013. The plant will be based on Casale's (formerly Borealis') Low Energy Melamine process, which produces high quality melamine at lower investment costs and energy consumption. The plant will be a completely stand-alone unit, using ammonia and CO_2 as feed, with a urea intermediate section which will also reprocess the off-gas from the melamine synthesis section and transform them into urea in order to recycle them back to the same section. Under the contract Casale will be responsible for licensing, basic engineering design and supply of key equipment. GSFC already operates two melamine plats in the same site, with a total production capacity of 15,000 t/a. The new plant is slated to be commissioned in 2018.

Government leaning towards coal-based production

Hansraj Ahir, India's Minister of State for Fertilizers and Chemicals says that the government is planning to set up at least 10 new coal-based urea plants in coal rich states of the country such as Chhatisgarh, Jharkhand, Bihar, West Bengal, Maharashtra, Uttar Pradesh and others where coal is available in large quantities. The first is targeted for Vidarbha's Chandrapur district, a joint venture between Rashtriya Chemicals & Fertilizers (RCF) and Coal India. The minister said that he has asked for a coal block to be allocated in order to initiate the project, and pointed to China's success in using coal to produce urea for domestic consumption. India consumes 31 million t/a of urea but produces only 22 million t/a, and imports the rest, mainly from China.

Government to set uniform gas price for urea producers

The Cabinet Committee on Economic Affairs, chaired by prime minister Narendra Modi, has approved a policy to supply gas at a uniform delivered price to all urea plants via a pooling mechanism, which aims to set a single uniform gas price allowing production of urea at less than the cost of importing it, encouraging existing producers to utilise their full capacity. The measure is expected to help in reviving the Gorakhpur, Barauni and Sindri urea plants on the Jagdishpur-Phulpur-Haldia (JPH) pipeline. As a result, work on this pipeline which was approved in 2007 is now finally expected to start this year. The Department of Fertilizer has estimated that the decision will lead to the additional production of around 370,000 t/a of urea in existing units over the next four years. Currently Indian urea producers pay a wide variety of prices for natural gas, according to whether they are supplied by domestic production or imports of LNG.

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

SAUDI ARABIA

Ma'aden returns to production, Safco V delayed

Saudi Arabian Mining Co (Ma'aden) says that it has restarted an ammonia plant after a brief shutdown for repairs at a cooling facility. The plant, at Ras Al Khair, was shut for almost 10 days from March 23rd. Ammonia was drawn down from stores and there was no impact on downstream production of diammonium phosphate, for which the ammonia is one of the major feedstocks, Ma'aden said in a statement.

In other news, Safco's new urea plant (Safco V) has seen its start-up delayed to mid-May 2015, according to the company. The plant, which has an annual production capacity of 1.1 million tonnes of urea, was originally scheduled to start up in the third quarter of 2014 but was delayed due to construction work falling behind the original timetable. In December, Safco said it had completed mechanical and construction work at the plant in Jubail and it would start trial operations lasting around three months to ensure the project could begin commercial production.

AUSTRALIA

Renewable ammonia plan

As part of the development of Western Australia's Pilbara region, already home to ammonia and ammonium nitrate production, the Pilbara Development Commission's Regional Investment Blueprint is looking into developing a 10MW solar farm and adjacent electrolysis plant which would provide hydrogen for local renewable ammonia production for export. Sydney-based RenewableHydrogen will be part of a feasibility study into the potential for a pilot plant as an initial step, near Karratha. RenewableHydrogen's Andrew Want said the Pilbara's sunshine, vast land and coastline meant it was well-placed to capitalise on Asia's move towards hydrogen fuel systems.

Nitric acid best for nickel leaching

Research at Curtin University indicates that direct solvent extraction ('DSX') using nitric acid could allow Australia to exploit more of its low grade nickel ore production. The process has been developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and Perth-based Direct Nickel. Dr Hutton-Ashkenny of Curtin said that his tests indicated that DSX will benefit Direct Nickel in terms of producing a purified nickel solution instead of a nickel-rich precipitate, by following up the nitric acid with pyridine carboxylate and a commercially available organic acid, Versatic TM10.

Existing processes tend to use sulphuric acid at high temperatures and pressure.

ISRAEL

ICL to develop potassium nitrate capacity

Israel Chemicals Limited (ICL) says that it is examining options to build a potassium nitrate plant to enable increased production of soluble fertilizers and food-grade phosphoric acid. The move is in line with the company's 'Next Step Forward' growth strategy to meet anticipated increased need for soluble specialty fertilizers, as well as for food-grade phosphoric acid.

The Company has initiated a feasibility study to determine the optimal location to construct the potassium nitrate plant based on considerations such as raw materials supply (including potash, phosphate rock and ammonia), logistical considerations, tax and investment encouragement policies and proximity to ICL's customers. ICL currently produces potash in Israel, England and Spain, and mines phosphate rock in Israel.

UNITED KINGDOM

IFS now selling complete AN and nitric acid proceedings

The International Fertilizer Society says that it has now collected all of its proceedings that relate to ammonium nitrate and nitric acid on to two new USB cards, with the same format as the previous one that the Society produced for proceedings relating to ammonia. Both are available at £180 including VAT, or £150 excluding it. IFS says that they provide a convenient and easily accessible way to access these unique collections, and contain essential information for use by plant managers, safety officers and all who have responsibilities for the safe production and handling of these materials, as well as those involved with the related regulations. Those interested should contact Steve Hallam, the Secretary of the International Fertiliser Society.

The Lifeco plant at Marsa El Brega.

LIBYA

Yara writes down Libyan investment

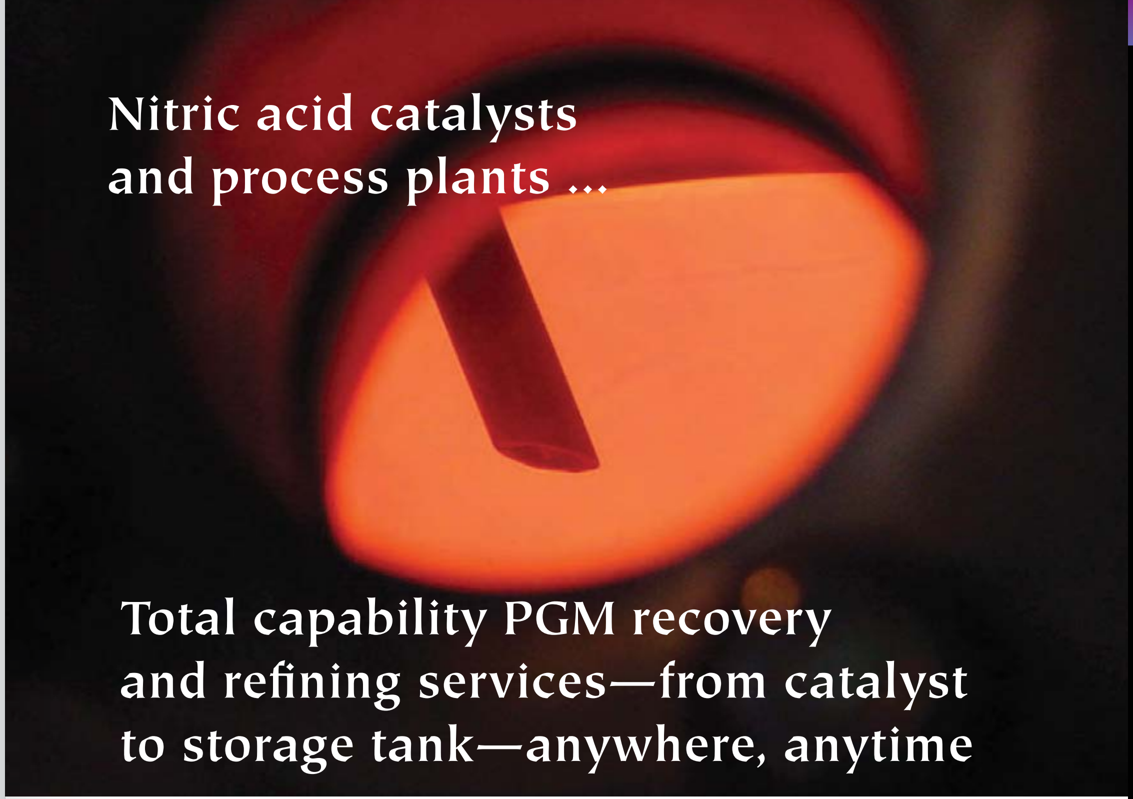
Yara has written down investment in its Libyan Lifeco joint venture by $112 million, leaving a value of $18 million for the project on its books. Yara owns 50% of the Marsa El Brega ammonia-urea complex on the Mediterranean coast, 700 km east of Tripoli, under a 2009 agreement with the National Oil Corporation of Libya (NOC) and the Libyan Investment Authority (LIA).

The Norwegian producer blamed the write-down on the "worsening security outlook" in the country and the "high likelihood of further deterioration in 2015". These security problems have compounded existing financial and feedstock difficulties faced by the joint venture. Yara said it was monitoring operations at Marsa El Brega to protect both its employees and assets. The firm will also continue to be involved in Lifeco's governance in the hope that full production can be resumed "once real improvements are seen in the security and political situation in Libya".

JAPAN

New catalyst could boost ammonia production

Work conducted by researchers at the Tokyo Institute of Technology has led to a new catalyst which – the institute claims – is so effective at promoting dissociation of the nitrogen triple bond – that it is no longer the limiting step in ammonia production. The N-N triple bond is one of the strongest in nature, and breaking it has required iron catalysts at very high temperatures and pressures in the Haber-Bosch process. However, collaboration between researchers in Japan, the UK and the US have developed a calcium-aluminium oxide compound which when complexed with ruthenium is stable at room temperature



CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Shell sulphur enhanced urea

and which catalyses nitrogen dissociation at less than half the activation energy of other catalysts. In addition the catalyst did not degrade due to hydrogen poisoning as is usually the case for ruthenium-based catalysts; both iron and ruthenium are well-known catalysts for breaking of the nitrogen bond, but ruthenium-based catalysts are highly prone to hydrogen poisoning where hydrogen adsorbs to the catalyst, so that for over a century iron-based catalysts have remained central to the ammonia production process. Alkali and alkaline earth metal oxides enhance ruthenium and iron catalysts by donating electrons into the 'anti-bonding orbitals' of the nitrogen, weakening the bond. This is referred to as the electronic promoting effect but has so far been difficult to harness for ammonia synthesis because the oxides are unstable in the reaction conditions.

NETHERLANDS

New sulphur-enhanced urea product

Shell has announced the development of *UreaPluS* technology, the second generation of its *Thiogro* sulphur-enhanced fertiliser technologies. *UreaPluS* technology enables fertiliser manufacturers to incorporate micronised sulphur particles directly into urea – an industry first – producing a differentiated sulphur-enhanced urea product. Via *Thiogro* Shell has already produced various high nutrient density grades of sulphur-enhanced urea, ranging from 7-18% elemental sulphur, over the course of two successful pilot runs at IFDC (the International Fertilizer Development Centre), in Muscle Shoals, Alabama. The team is now focused on testing this product in agronomic and scientific trials, and integrating the technology with various urea forming technologies. *UreaPluS* technology utilises patented micronisation technology to emulsify the particles of elemental sulphur evenly throughout the urea, forming a homogeneous granule, in contrast to existing elemental sulphur-containing urea technologies, which typically coat urea in a layer of elemental sulphur. The microscopic size of the sulphur particles, at under 40 micrometres (µm), promotes the oxidation of the sulphur within the crop season.

It is expected that the technology will also be able to incorporate micronutrients like zinc and boron into the granule, enabling urea manufacturers to produce customised grades that meet local needs. This new technology follows in the footsteps of Shell *Thiogro* phosphates technologies, which have enabled fertiliser producers to safely incorporate micronsized particles of elemental sulphur and other nutrients into some of the most widely used phosphate fertilisers, including MAP, DAP, TSP and NPKs.

"As Shell's integrated sulphur management business, we are proud to be able to help meet the global demand for sulphur as a plant nutrient by launching a technology that can deliver sulphur to plants through the most widely-used nitrogen fertiliser in the world – urea," said Mike Lumley, General Manager of Shell Sulphur Solutions.

EUROPEAN UNION

Commission raises anti-trust case with Gazprom

The European Commission has sent a Statement of Objections to Gazprom alleging that some of its business practices constitute an abuse of its dominant market position in breach of EU anti-trust rules. As the dominant gas supplier in a number of central and eastern European countries, Gazprom has a market share well above 50% and in some cases up to 100% in these markets. In light of its anti-trust investigation, the Commission's preliminary view is that Gazprom is hindering competition in the gas supply markets in eight central and eastern European member states (Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland and Slovakia), by: (i) hindering cross-border gas sales, (ii) charging unfair prices, and (iii) making gas supplies conditional on obtaining unrelated commitments from wholesalers concerning gas transport infrastructure.

A Statement of Objections is a formal step in Commission investigations into suspected violations of EU antitrust rules. The addressees can examine the documents in the Commission's investigation file, reply in writing and request an oral hearing to present their comments on the case before representatives of the Commission and national competition authorities. The Commission says that it then takes a final decision only after the parties have exercised their rights of defence.

The case has in fact been under investigation for nearly three years, and the fact that it is now moving forward may owe as much to the state of EU-Russian relations over Ukraine as anything else. By formally charging Gazprom, the commission doesn't rule out the possibility of a settlement, which Gazprom is said to be seeking, but the Putin government may not allow it to.

IRAN

Plans for urea joint venture resurface

Plans to build joint Indo-Iranian ammonia urea complex, abandoned over a decade ago after the project partners were unable to agree on a gas price, have resurfaced as the Indian government looks at all possible ways of tackling the country's growing deficit in urea fertilizers. Ananth Kumar, the Indian Minister for Chemicals and Fertilisers, told local press: "In order to ensure long term availability of urea in the country, the government is facilitating setting up of a urea/ ammonia joint venture project in Iran with capacity to produce 1.3 million tonnes of urea for import to India." The project is reportedly at a consultation stage, with Indian firms Rashtriya Chemicals and Fertilizers, Gujarat State Fertilizers and Chemicals and Gujarat Narmada Valley Fertilizer and Chemicals appointing a broker to look for suitable joint venture partners. The proposed 600,000 t/a Indo-Iranian Kharg Island ammonia plant project was finally abandoned in 2003. ■

CONTENTS
What's in issue 335

COVER FEATURE 1
Urea markets

COVER FEATURE 2
India's subsidy policy

COVER FEATURE 3
CO_2 in methanol production

COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

UNITED KINGDOM

Shell agrees terms for BG takeover

Shell has offered to acquire BG Group's entire share capital for around £47 billion ($70.2 billion). The boards of both companies have recommended their respective shareholders to endorse the acquisition. Shell says the combination would accelerate its growth in global LNG and deep water exploration and production, particularly in Australia and Brazil. It would add around 25% to Shell's proven oil and gas reserves and 20% to its production, each on a 2014 basis.

Shell CEO Ben van Beurden said: "BG and Shell are a great fit. This transaction fits with our strategy and our read on the industry landscape around us. This transaction will be a springboard for a faster rate of portfolio change, particularly in exploration and other long-term plays."

BG CEO Helge Lund, who only joined recently from Statoil, said: "The offer from Shell... has strong strategic logic. BG's deep water positions and strengths in exploration, liquefaction, and LNG shipping and marketing will combine well with Shell's scale, development expertise and financial strength."

Oil and gas discovery in southern England

The exploration company UK Oil & Gas Investments claims that it has made a significant oil find close to Gatwick Airport in West Sussex. The company made waves in the local media by announcing the results of an analysis conducted on the site which indicated that the well could yield up to 158 million barrels of oil per square mile. The company's licenses cover 55 square miles of the Weald Basin, a region spanning Kent, Sussex, Surrey and Hampshire. This suggests that the site could hold over 8.6 billion barrels of oil about 20% of the reserves of the UK North Sea, although only a fraction – UKOG has estimated about 15% – may be recoverable, especially at current prices, and the company later issued a 'clarification' that estimates "should not be considered as either contingent or prospective resources or reserves."

"The company has not undertaken work outside of its licence areas sufficient to comment on the possible OIP [oil in place] in either the approximate 1,100 square miles or the whole of the Weald Basin," the company has said, adding: "Further development work in the form of appraisal drilling, well testing and assessment of recovery factors will be required to seek to quantify net resources in relation to the Company's licence areas and to prove its commerciality."

Last year the British Geological Survey estimated that there are 4 billion barrels of shale oil in the wider Weald Basin.

UNITED STATES

Celanese considering second methanol plant

Celanese and Mitsui & Co have agreed to explore a joint venture for a second 1.3m tonne/year methanol plant at Celanese's integrated chemical production site in Bishop, Texas, according to Celanese. The company has filed for air permits with the Texas Commission on Environmental Quality for a potential methanol unit in Bishop. A final decision will consider prevailing methanol market conditions and construction costs. The facility is expected to be based on the current Celanese-Mitsui joint venture methanol plant currently under construction at Clear Lake, Texas, saving on design and engineering costs. That facility is due to come on-stream in 3Q 2015.

BASF selects Texas for planned methanol-to-propylene complex in US

BASF has selected Freeport, Texas, US, as the potential site for its planned petrochemical complex on the US Gulf Coast, making use of natural gas feedstock. The facility will feature Lurgi *MegaMethanol* and methanol-to-propylene technologies, to produce 475,000 t/a of petrochemical product from natural gas. Air Liquide has been awarded a contract to manage basic engineering activities for the gas-to-propylene complex. The methanol-to-propylene project is subject to final approval from BASF board of executive directors in 2016, and would be the company's largest single plant investment to date, part of the company's plan to strengthen its backward integration into propylene and grow its propylene-based downstream activities.

EGYPT

BP signs off on $12 billion gas development

BP has signed the final agreements of the West Nile Delta ('WND') project to develop 5 trillion cubic feet (tcf) of gas resources and 55 million barrels of condensates with an estimated investment of around $12 billion by BP and its partner. Production from WND is expected to reach up to 1.2 billion cubic feet a day (bcf/d), equivalent to about 25% of Egypt's current gas production. All the produced gas will be fed into the country's national gas grid, helping to meet the anticipated growth in local demand for energy. Production is expected to start in 2017. Gas will be produced from two BP-operated offshore concession blocks, North Alexandria and West Mediterranean Deepwater. BP believes that there is the potential through future exploration to add a further 5-7 tcf which could boost WND production with additional investments. BP expects to double its current gas supply to the Egyptian domestic market during this decade when the WND project reaches peak production.

BP has also recently made major gas discoveries in the East Nile Delta. The Atoll 1 well in the North Damietta Offshore Concession reached 6.4 km depth and penetrated approximately 50 metres of gas pay in Oligocene sandstones. Commenting on the discovery, Hesham Mekawi, BP North Africa Regional President said: "The Atoll discovery is a great outcome for our second well in this core exploration programme in the East Nile Delta. It demonstrates BP's continuous efforts to help in meeting Egypt's energy demands by exploring the potential in the offshore Nile Delta. We are proud of our commitment to unlock Egypt's exploration potential that requires large investments to utilise using the latest drilling and seismic technologies."

CHINA

Collaboration on fluid bed MTG process

ExxonMobil is to join forces with Sinopec to develop fluid bed process for converting methanol to gasoline (MTG). The partnership pairs ExxonMobil experience in first generation fixed-bed MTG processes and research into fluid-bed designs conducted

CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

in the 1980s with Sinopec Engineering Group's wider experience of developing fluid bed technologies. Pilot facilities have already been built at Sinopec Engineering Group's research facilities in Luoyang, China.

"Our goal is to develop a fluid bed MTG design that will cost significantly less to construct and operate," said Xuejun Xiao, director of the technical department of Sinopec Engineering Group. "We want to significantly improve energy efficiency versus the fixed bed design."

The fixed bed design was developed by ExxonMobil in the 1970s and 1980s and was first commercialised at a 14,500 bbl/d plant in New Zealand in 1985. Gas and coal conversion to methanol and methanol conversion to fuels is commercially proven, and has the advantage of providing a simpler route without traditional refining to saleable fuels, according to ExxonMobil.

Ordos SNG project receives water resource approval

Inner Mongolia Beikong Jingtai Energy Development Co. has received water resource approval from the Yellow River Water Resources Commission of the Chinese Ministry of Water Resources, for its 4 billion m^3/yr coal to SNG project in Ordos, Inner Mongolia. This project received preliminary approval from the NDRC in March last year. To be constructed in the Dalu Industrial Park, Zhungeer County, Ordos, with a total capacity of 12 billion m^3/year coal to SNG, the project is being jointly developed by CNOOC, Beikong and Heibei Construction Investment, each with a total capacity of 3×4 billion Nm^3/a. The associated power island will be constructed by Heibei Construction Investment with twin 350MW thermal power units.

Successful outing for novel propane dehydrogenation technology

Clariant says that its Heat Generating Material (HGM) for the *Catofin*® process has demonstrated excellent performance at the propane dehydrogenation plant of Ningbo Haiyue New Material Co. Ltd in Ningbo City, China. The plant produces 600,000 t/a of propylene using the Chicago Bridge & Iron Catofin catalytic dehydrogenation process, based on Clariant's Catofin catalyst. The Catofin process operates at optimum reactor pressure and temperature to maximise conversion of propane, and HGM is an innovative metal oxide material which is designed to significantly increase selectivity and yield of Catofin units. The material is loaded into the catalyst bed with the catalyst where it undergoes oxidation and reduction during the operating cycle, producing heat and driving the dehydrogenation reaction. Several Catofin units using HGM for isobutylene production have gone on-stream since 2011, but Ningbo Haiyue is the first PDH plant to operate using HGM.

New hydrogen plant

Shanghai Huaxi Chemical Industry Science and Technology Co. Ltd has signed a contract with Jiangsu Weiming Petrochemical Co. Ltd for the delivery of a 12,000 Nm^3/h hydrogen plant. The plant will reform natural gas and will supply hydrogen to the caprolactam unit of Jiangsu Weiming, a subsidiary of the Taiwan China Petrochemical Development Corporation (CPDC). The plant is CDPC's first caprolactam project in China.

INDIA

SES and Simon India extend joint marketing agreement

Synthesis Energy Systems and Simon India Ltd have extended their exclusive marketing and engineering agreement to market SES' advanced technology for coal and biomass gasification projects in India. SIL, an engineering, procurement and construction (EPC) company, is a wholly owned subsidiary of Zuari Global Limited. Zuari and SIL are member companies of the Adventz Group, a $3 billion Indian conglomerate comprising 23 companies in various industries, including high-quality complex fertilizers. SES' gasification technology is suited for the high-ash, low-grade coals that comprise upwards of 80% of India's coal reserves. SIL has been leading the introduction of SES technology to India customers for large scale fertilizer, substitute natural gas (SNG), liquid fuels, direct reduced iron (DRI) for steel manufacturing, and power generation projects. In addition to promoting SIL as its preferred EPC provider for projects utilizing SES gasification technology in India, SES will continue to exclusively use SIL for both marketing assistance and assisting on SES' process design package engineering work it performs for any Indian gasification projects that SES is awarded.

India has begun to take more aggressive steps towards the implementation of coal-gasification based projects to increase the country's energy independence and use of local energy resources. Additionally, expensive imported natural gas and oil is propelling private and government entities to more rapidly develop coal gasification projects such as large-scale fertilizer projects converting local Indian coal into syngas which is used to make ammonia and other fertilizer products. SES and SIL are currently responding to requests for proposals for projects which intend to finalize their project investment decisions during the course of this year.

"We value the relationship we have built with our long-term partner, Simon," said Robert W. Rigdon, SES President and CEO. "The improved Indian business environment and coal allocations process, combined with growing GDP and expensive natural gas and imported LNG alternatives, has opened up this rapidly emerging market opportunity… we are seeing an increased volume of project inquiries in India as a result. We are currently working together on two near-term large project evaluations: for coal to ammonia, and coal to DRI steel."

TRINIDAD & TOBAGO

New methanol plant for Trinidad and Tobago

Mitsubishi Corporation and Mitsubishi Gas Chemical (MGC) have signed a project development agreement to build a $1 billion methanol and dimethyl ether (DME) plant at La Brea in Trinidad and Tobago. The deal was signed with the national government and local partner Neal and Massy Holdings, which owns companies in many industries including industrial equipment, logistics, IT and energy and industrial gases. The new plant will produce 1.0 million t/a of methanol and 100,000 t/a of dimethyl ether from natural gas produced in Trinidad and Tobago.

Mitsubishi Corporation says that the global demand for methanol is forecast to grow by 4–5% in the coming year. It plans to sell the methanol produced at the new plant on the global market. Dimethyl ether (DME) has been generating much interest as a potential substitute for LPG in vehicles and to generate electricity. DME has similar physical properties to LPG and does not emit particulate matter, NOX or sulphur oxides. Mitsubishi and MGC will work with the Trinidad and Tobago government and Neal and Massy to promote the use of DME.

"By using natural gas produced in Trinidad and Tobago as the main source of raw materials for producing methanol, a basic chemical, and dimethyl ether, a liquefied gas, the project will be making a contribution to economic growth in Trinidad and Tobago and the Caribbean region while at the same time helping to satisfy the growing global demand for methanol," says Mitsubishi in a statement.

The plant is expected to begin commercial operations in 2016. The partners plan to develop other downstream petrochemical plants in Trinidad and Tobago in the future.

ICELAND

CRI to promote power to methanol technology

Carbon Recycling International (CRI) and Mitsubishi Hitachi Power Systems Europe (MHPSE) have entered a strategic alliance to deliver power-to-methanol solutions and increase the operating efficiency of coal power and chemical plants. The companies have decided that power-to-methanol is a viable technology for large-scale storage of wind and solar power. As part of the alliance, both companies will market and deliver CRI's power-to-methanol technology, trialled on a geothermal energy site in Iceland, as well as MHPSE's experience in thermal power systems to allow power plants to operate at economic capacity levels and produce methanol as a side stream even when large variations in demand and supply are imposed by intermittent electricity from renewable sources on the grid. The firms will also be responsible for offering energy upgrade solutions to chemical manufacturers for hydrogen recovery and CO_2 capture from flue gas to produce low-carbon intensity methanol.

Since 2012, CRI has been operating its power-to-methanol production plant in Iceland, which produces low carbon intensity methanol that is used for biodiesel manufacturing and gasoline blending. The production plant has recently been expanded to 4,000 t/a.

MHPSE chief sales officer and member of the board Dr Matthias Jochem said: "With a growing share of energy from solar and wind power on the electric grid, coal power plants need to meet greater variations in power demand to maximise operating capacity and plant efficiency. This goal can be accomplished immediately with Carbon Recycling International's unique power-to-methanol solution, which allows power plants to use excess capacity to store energy efficiently in liquid fuel, which is easily stored or transported."

SOUTH AFRICA

Fuel cell power for Impala

Imapala Platinum is building a new fuel cell-based power plant at the company's refinery in South Africa. The company is one of the largest metal producers in the world, but demand for the metal it produces has begun to fall, as well as the price of this metal. Fuel cells will be used to produce the power than the company needs, with the hydrogen feedstock for the fuel cells produced through the metal refining process. Each fuel cell will generate 1.8 MW of electrical power. The hydrogen fuel cells will be of conventional design, using platinum catalysts in order to convert the hydrogen fuel into energy. Impala is looking to avoid energy shortages due to the struggles that South Africa's primary utility, Eskom, is facing with meeting the demand for the electrical power it produces.

The project will be two phases, with the first phase involving the use of hydrogen fuel cells to produce electrical power. During the second phase, Impala says it will use fuel cells that use natural gas and hydrogen to produce energy, which generate as much as 22 MW of energy, enough to meet the needs of the entire power plant. Impala says it is also considering using fuel cells as its primary energy source in the future.

WORLD

World hydrogen market to reach 325 bcm by 2020

According to a new market report published by Persistence Market Research, the global hydrogen market was valued at 255.3 billion cubic meters in terms of volume and $96.6 billion in terms of value in 2013. It is expected to grow at a compound annual growth rate (CAGR) of 3.5% and 5.6% of volume and value respectively from 2014 to 2020, to reach an of 324.8 billion cubic meters in terms of volume and $141.4 billion in terms of value by 2020.

According to the report, growing secondary end-user industries and increasing use of hydrogen in refinery hydroprocessing are some of the major factors fuelling the growth of the hydrogen market for hydrogen fuel cell vehicles. Since the hydrogen is used in petroleum refining processes, the industry is impacted by the unstable growth of the latter. However, increasing demand for clean transportation (the reason for unstable growth of petroleum refining industries) is supporting growth of the hydrogen market in terms of increasing demand for hydrogen fuel stations. Demand for hydrogen in refining has increased significantly over the last few years owing to stringent motor vehicle emissions regulations imposed by various governments.

Hydrogen filling station, California.

Asia-Pacific is the largest market for hydrogen globally. Increasing demand from countries such as India and China coupled with increasing use of hydrogen in secondary end-user industries is expected to propel the growth of the Asia-Pacific market. Some of the major factors contributing to the growth of hydrogen market in North America include stringent motor vehicle emission regulations imposed in developed countries, including the US. This, in turn, is increasing demand for low sulphur and ultra-low sulphur gasoline and diesel fuels.

The global hydrogen market grew from 232 bcm in 2010 to 255 bcm 2013 at a CAGR of 3.2% in terms of volume, and from $82.6 billion in 2010 to $96.6 billion at a CAGR of 5.3% in terms of value. Regionally, the Asia-Pacific hydrogen market (the largest market in 2013) increased by 6.8% CAGR during 2010-2013 to reach 81.1 bcm in 2013. The Linde Group dominated the hydrogen market with a 20% share in 2013, followed by Air Liquide and Praxair. with 18% and 12% shares respectively. Other major companies in the global hydrogen market are Messer Group GmbH, Airgas, Inc., Taiyo Nippon Sanso Corporation, Iwatani Corporation, Hydrogenics Corporation, Air Products and Chemicals, Inc., and Showa Denko K.K. ■

CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

People

There have been further changes at the top of Yara. Last year the company had four executives indicted for corruption over dealings with Libya, and then in the wake of the failed merger with CF Industries lost its new incoming CEO Richard Brandtzaeg and previous CEO Jorgen Ole Haslestad. Now **Egil Hogna**, senior vice president and head of downstream activities has also tendered his resignation. Yara says that it has appointed **Terje Knutsen** to be head of its downstream business unit effective from May 1st to manage the company's global sales, marketing and distribution of fertilizers. Knutsen currently oversees Yara's downstream activities in northern and eastern Europe. Prior to this, he was head of the company's Asian business unit. "His competence will be highly valuable as Yara continues its efforts to support a more efficient and climate-smart agricultural sector," said Yara Acting CEO **Torgeir Kvidal**.

Torgeir Kvidal himself is set to continue as CEO for another six months before resuming his previous position as chief financial officer. At the same time, **Thor Giæver**, currently acting CFO, will return to his position as Head of Investor Relations. **Svein Tore Holsether** will succeed Kvidal as CEO in October this year. Holsether currently serves as President and CEO of Sapa Group, a position he has held since 2011. Prior to this, he held a number of management positions in Elkem, Orkla and Sapa. Holsether was born in Norway in 1972 and holds a BSc in Finance from the University of Utah.

"Svein Tore Holsether is a perfect fit for Yara, and the Board of Directors is very satisfied that he has decided to join the company. His extensive background from international industry coupled with his personal capabilities makes him highly qualified for the position as CEO," said Leif Teksum, Chairman of the Board of Directors of Yara.

"I am very pleased to have the opportunity to join Yara. The company performs very well and holds a unique position throughout its global footprint. In a time of many worldwide challenges, I look forward to working on solutions addressing issues of fundamental needs like food security and protection of the environment," said Svein Tore Holsether.


Jonathan Sabin

Jonathan Sabin has been named president at the Sabin Metal Group of Companies, the largest independently owned, secondary precious metals refining organization in North America. He takes over from his father, Andrew Sabin, now the company's chairman, and represents the fourth generation of the family owned business which began with his great grandfather.

Sabin has been with the organization for the past 15 years, overseeing precious metals recovery/refining, managing sampling and assaying processing, and serving in numerous administrative capacities. He graduated from the University of Michigan with a BGS degree in business and languages, and is also a board member at the South Fork Natural History Museum and the Andrew Sabin Foundation. Before joining the company, Sabin traded currencies at the Union Bank of Switzerland in New York. He is an aviation enthusiast, having obtained his private pilot's license at the age of 17, and is married and the father of four children. ■

Calendar 2015

MAY

25-27

83rd IFA Annual Conference, ISTANBUL, Turkey. Contact: IFA Conference Service, 28 rue Marbeuf, 75008 Paris, France.
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

JUNE

7-10

International Methanol Technology Operators' Forum, LONDON, UK.
Contact: Johnson Matthey
Tel: +44 +44 (0) 1642 553601
Email: imtof@matthey.com

11-12

26th IMPCA European Mini-Conference, Europe. Contact: IMPCA, Avenue de Tervueren 270 Tervurenlaan, 1150 Brussels, Belgium. Tel: +32 (0) 2 741 86 83
Fax: +32 (0) 2 741 86 84
Email: info@impca.be

22-26

IFDC/IFA Nitrogen Fertilizer Production Technology Workshop, VIENNA, Austria.
Contact: IFDC, P.O. Box 2040, Muscle Shoals, Alabama 35662, USA.
Tel: +1 256 381 6600
E-Mail: training@ifdc.org

AUGUST

31-3 SEPTEMBER

AIChE Ammonia Safety Symposium, BOSTON, Massachussets, USA.
Contact: AIChE Customer Service
Tel: +1 800 242 4363/
+1 212 591 8100
Fax: +1 212 591 8888
Email: xpress@aiche.org

SEPTEMBER

21-23

IFA Production and International Trade Conference, Florida, USA.
Contact: IFA Conference Service,
28 rue Marbeuf, 75008 Paris, France.
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

OCTOBER

4-9

Ammonium Nitrate/Nitric Acid Conference, JASPER, Canada.
Contact: www.an-na.org/2015-conference

26-28

Asian Nitrogen+Syngas Conference, JAKARTA, Indonesia.
Contact: CRU Events,
Chancery House,
53-64 Chancery Lane,
London WC2A 1QS, UK.
Tel: +44 20 7903 2444
Fax: +44 20 7903 2432
Email: conferences@crugroup.com

NOVEMBER

10-12

World Methanol Conference, MUNICH, Germany.
Contact: Lynn Urban,
Sales Manager,
IHS Events.
Tel: +1 303 397 2801
Email: Lynn.Urban@ihs.com

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Plant Manager+

Problem No. 30 What is the best stainless steel for urea?

Ammonium carbamate is an intermediate product in the production of urea from carbon dioxide and ammonia. Ammonium carbamate is very corrosive under the synthesis conditions in a urea plant. The various process licensors have developed different solutions to assure sufficient safety and reliability levels. In the early days titanium and 316L Urea Grade stainless steels were applied. The process conditions in the high pressure stripper are the most severe, i.e. the highest temperatures and lowest oxygen partial pressures are present. A new stainless steel 25-22-2 with a higher chromium content was developed specifically for the high pressure CO_2 stripper. Super duplex materials like Safurex® and DP28W™ and Omega-Bond™ (a combination of zirconium with titanium) are the latest developments and have proven to be better than earlier materials, but what is the best material?

Mr Janusz Maćkowski of Zch Police in Poland starts the Round Table discussion: What is the best material for the stripper (tubes and liner) and the other synthesis equipment in a urea plant: Safurex®, Super duplex, DP28W™ (Sumitomo), bimetallic with Zr/25-22-2, any others? What is the actual level of oxygen they need? What is the best material for the urea reactor liner?

Mr Mark Brouwer of UreaKnowHow.com in the Netherlands responds: Maybe titanium should also be on your list. In addition, Saipem has developed a new type of tube material for the stripper (Omega-Bond™). Looking at the "best" materials I believe several different aspects are important:

- intrinsic resistance against corrosion (for example zirconium is better then 25-22-2)
- need of oxygen for passivation
- weldability (here zirconium is much worse)
- sensitivity to problems like erosion, H_2 embrittlement, chloride SCC, crevice corrosion (bimetallic) etc.
- price
- references.

Considering all these, Safurex® is in my opinion the best choice for urea synthesis conditions. It also has the potential to work under zero oxygen conditions.

Janusz replies: Thank you for your reply. Omega-Bond™ is bimetallic (Ti/Zr). I know that Safurex® is very good. Super duplex with tungsten is also very interesting (DP28W™). I think this material could have similar features to Safurex® (or even better) but it is quite a new material (very few references in comparison to Safurex®). Does anyone have experience with this material?

Mr Waqqar Ahmed of Fauji Fertilizer Company Ltd. in Pakistan joins the discussion: Saipem's technology uses 316L Urea Grade (UG) or Modified (Mod) and 25-22-2 and 0.35 vol-% of oxygen in CO_2 feed is sufficient for passivation. We have experience of both titanium and bimetallic (25-22-2/Zr). Titanium has excellent corrosion resistance but it has erosion problems. With additional passivation air at the bimetallic urea stripper bottom, we found no problem even when operating at 205-206°C. 3 ppm of oxygen at the stripper bottom is enough for passivation of 25-22-2 tube sheet and tube ends. Safurex® has excellent corrosion resistance, but can it sustain its corrosion resistant properties at temperatures up to 205-206°C without passivation air? With Omega-Bond™ strippers Saipem claims the stripper bottom can even be operated at a temperature of 210°C.

Mr Fabiano Parizotto of Petrobras in Brasil shares his experiences: Take care with Safurex®, because one can find corrosion in machined parts which have suffered during the fabrication process. This corrosion phenomenon is called "stern face corrosion". This corrosion occurs due to the break of grains, which reduces the corrosion resistance. Check parts such as the hole in tubes, dividers or clips to attach trays, etc.

Mark replies: It was indeed true that the first generation Safurex® was more sensitive to cross cut end (or stern face corrosion). In the later generations Safurex® this problem has been solved. Further, a Safurex® stripper was successfully in operation at the Saipem urea plant of Profertil in Argentina and is now in operation at Agrium Redwater in Canada, so yes Safurex® can also handle 205-206°C. I do not know whether these plants had extra passivation air injection on the stripper.

Mr Jan Cervenka of Chemoprojekt Nitrogen in Czech Republic asks some questions: Is it possible to protect the machined parts Fabiano refers to, e.g. by some kind of grinding (mechanical way) or pickling (chemical way)? What can be done at the workshop (after machining/welding) and what can be done with already corroded surfaces?

Mr Eddie Canadilla of SAFCO in Saudi Arabia adds: How does Safurex® handle stern face attack (or cross cut end attack) where other urea grade stainless steels are not so effective?

Mark replies: Grinding or pickling can be used to remove oxides, which occur after machining or welding. Removal of these oxides is important in order that a proper passivation layer can built up as explained in one of Giel Notten's Technical Papers (for example UreaKnowHow.com Mechanical Paper February 2009). This is applicable for austenitic stainless steels like 316L Urea Grade (UG) or 25-22-2 usually applied in urea plants. Also after severe active corrosion of these materials it is advisable to apply picking to remove these excessive corrosion products and enable the build up of a proper passivation layer. Safurex® is a duplex stainless steel, a mixture of austenite and ferrite material and more specifically the Safurex® structure is such that there are austenite islands in a ferrite matrix. Passivation is therefore not necessary any more (Safurex® urea plants may not need oxygen for passivation). In first generation Safurex® this structure had not been optimised at cross cut ends. In later generations it was improved and better fabrication procedures were developed to minimise the problem of cross cut end corrosion.

Mr Muhammad Kashif Naseem of SABIC in Saudi Arabia shares his experiences: Toyo Engineering Corporation (TEC) uses DP28W™ material for the stripper tubes, the tubesheet carbamate side and the liner in the top and bottom chamber of this stripper in ACES21 technology. There is also very good experience with this material and it shows better corrosion resistance.

Janusz requests more information: I would like to know the corrosion rate for different urea stainless steels, especially for the following: 316L UG, 25-22-2 and Safurex®.

Mark replies: All corrosion rates strongly depend on temperatures. In addition, we should make a distinction between passive corrosion rates and active corrosion rates.

As a rough guide passive corrosion rates of the tubes in a high pressure CO_2 stripper are:

BC.05 (25-22-2): 0.06-0.07 mm/yr
BE.06 (Safurex®); 0.05-0.06 mm/yr

Further, the sensitivity for active corrosion for the various materials is as follows:316L UG > 25-22-2 > Safurex®. And then we can distinguish for chloride SCC: Safurex® not sensitive and 316L UG and 25-22-2 sensitive.

Janusz asks: Does anyone know the corrosion rate of 316L material for a HP CO_2 stripper and reactor? Can AISI 904L (1.4539) material be used in urea synthesis (especially for renovating valves)?

Mark replies: 316L material or 316L UG can be used efficiently in urea reactors. Corrosion rates vary between 0.2 and 0.05 mm per year on stream (pyos). Whether 316L can be used depends on the amount of alloying elements. Cr and Mo play a very important role and of course the carbon content, the higher the Cr content in combination with a low carbon content gives the best results and that is obvious when you review the chemical composition of the urea grade 316L types. A regular 316L may end up with corrosion rates of over 0.5 mm pyos and in the worst case up to 2 mm per year. Also welding 316L will have a negative effect on selective corrosion as there is weld decay and sigma phase. As regards 316L in strippers, the wall temperature in a stripper is far too high for even a Urea Grade 316L type, the first HP CO_2 strippers had 316L UG tubes and the tubes lasted only a few months. This material is completely inadequate for stripper tubes. Lliner overlay welds and internals can be made in Urea Grade 316L but with the addition of sufficient oxygen. Cross cut end attack is greater for all austenite and austenitic-ferritic (duplex) materials higher than surface corrosion. For duplex this attack is greater due to the micro structure of these materials. When discussing Safurex®, the surface attack looks higher because the surface attack is negligible here. The cross cut end attack is not higher than for other duplex materials.

AISI 904L is not a good material for urea service, it is relative low in Cr and very high in Ni. It can be compared with Sandvik type 2RK65 and is useful in a seawater environment

Mr Pradeep Pednekar of RCF Ltd Thal in India shares his experiences: We have Saipem technology in our urea plants 3 x 1,725 t/d design capacity. In Saipem plants 316L UG and 25-22-2 (2RE69) are used and 0.35 vol-% oxygen in the CO_2 feed is sufficient for passivation. Previously we were using titanium strippers. Titanium has excellent corrosion resistance but it has problem with erosion. With bimetallic strippers passivation at the bottom of the stripper is a must. With additional passivation air at the bimetallic urea stripper bottom, we experienced no problems even when operating at 205-206°C. 3 ppm of oxygen at the stripper bottom is sufficient for passivation of 25-22-2 tube sheets and tube ends. For high pressure carbamate condenser tubes 25-22-2 is the best.

Janusz asks some more questions:

- What is the safe minimum thickness of the reactor liner with 316L UG stainless steel?
- What level of nickel (Ni) in urea solution from the urea reactor (316L UG) is normal and what level of nickel is emergency?
- What is an average lifetime of urea reactor liner (316L UG)?

Mr Prem Baboo of National Fertilizers Ltd. in India shares his experiences: In our Saipem urea plant, commissioned in April 1987, the reactor liner thickness is still 6.8-7.1 mm. If one regularly checks the weep holes, performs maintenance during the shutdown (dye penetrant test and pitting maintenance), etc. then the life of urea reactor can be increased. Passivation air flow i.e oxygen in the 3rd stage compressor should not be less than 0.35%. The top temperature of the reactor should not exceed more than 190°C. The level of nickel (Ni) in urea solution from the urea reactor (316L UG) is 40-45 ppb. Below is an overview of the various materials applied in carbamate service in urea plants.

Titanium: Titanium is used in the relatively pure state. It has excellent corrosion resistance but is one of the more costly materials and more difficult to weld. The corrosion resistance of titanium is due to the impervious oxide film i.e. 100% TiO_2 film on the surface. Titanium is resistant to stress-corrosion cracking and erosion corrosion, but is susceptible to crevice corrosion in stagnant chloride solutions. Titanium was used for the lining and tube material of the high pressure NH_3 stripper in Saipem urea plants. Commercially pure titanium exhibits a high resistance to pitting attack. Titanium has also been used for the lining of urea reactors in TEC urea plants. The advantages are that less passivation air is required compared to other stainless steesl and the HP NH_3 stripper bottom temperature in the urea plant can be kept at temperatures of up to 210°C while with a bimetallic stripper the temperature cannot be raised beyond 207°C. The disadvantages are that titanium is not maintenance friendly due to the difficulty in welding and erosion of tubes ends resulting in bypassing in the stripper due to tube end over ferrules badly eroded by carbamate solution.

Zirconium: The corrosion resistance is because of the ZrO_2 layer. Zirconium is more expensive than titanium (roughly twice that of titanium).

316L UG and 25-22-2: These are tailor made grades of austenitic stainless steel to suit required specifications of licensor. The rate of corrosion as per the Huey Test is as follows:

Material	Corrosion rate (mm/yr)
Zirconium	0.005
Titanium	0.06
25-22-2	0.3
316L UG	0.6

Duplex stainless steels: Duplex steel is characterised by a microstructure containing both a ferritic phase with a BCC crystallographic structure and an austenitic phase with a FCC structure. The ferritic phase is normally 40-60%, mainly introduced in the wrought alloys by a careful balance of the critical alloying elements. It has a higher strength and better resistance to chloride stress corrosion cracking. ■

CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening
NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

India's nitrogen policy

India faces increasing imports of urea at the same time as gas shortages prevent development of new capacity and producer subsidies weigh heavily on the treasury. Narendra Modi's government seems keen to cut this Gordian knot, but how?

It has now been a year since Narendra Modi won the election that led to him becoming India's new prime minister. There have been considerable expectations about Modi's government in many quarters, but not least in the arena of fertilizers, one of India's crucial industries.

The business world was hoping for a number of eye-catching reforms to kick-start growth. Certainly GDP numbers seem to have been given a boost, rising from 4.5% growth in the 2013 financial year to 6.9% for the 2014 financial year. The falling rupee against the stronger dollar and low international oil prices have also most assuredly played their part in this, as India imports two thirds of its oil requirements from overseas. The index of industrial production appears to be moving in the right direction, and there is growth in important sectors like manufacturing, mining and electricity. However, inflation has fallen so fast as to become negative, which is not a good sign for an economy.

With the slackening of growth in China, investors have hoped that India would provide the next growth story, with GDP increases rising back towards the figures of 8-9% per year that the country saw last decade. The jury is still out on this. However, what is certain is that India's agriculture and industry both need a thorough revamp if the Indian economy is to boost its productivity, as well as continuing its goal of maintaining food security.

Agriculture

India's population now stands at around 1.25 billion, rising towards 1.6 billion by 2050, and overtaking China some time around 2025. Feeding this many people is a perennial challenge, which occupies 65% of India's workforce and which is responsible for 17% of the country's GDP. India did achieve self-sufficiency in food grain production in the 1990s, but growth in food production has since failed to keep pace with increasing population. Nevertheless, from around 240 million t/a in 2010, food grain production did rise to 265 million t/a in the 2013-14 financial year, although it is estimated to have fallen by 3% for the 2014-15 year due to a delayed monsoon.

The Indian parliament passed a National Food Security Bill in 2013, making food security mandatory for around two-thirds of the population. The bill expanded a pre-existing food subsidy scheme to cover about 180 million of the country's poor, who collectively will receive around 4 million tonnes of food grain every month at a fair price through licensed shops. In effect, nearly 75% of the rural population (630 million) and 50% of the urban people (180 million) will be eligible for grain at a cheaper rate in future. In order to achieve this, food grain production will need to rise from the present 265 million t/a to 320 million t/a by 2020. Increasing food yield by 20% in just five years is a tall order, and will require advances to be made in many areas, not least in balanced fertilizer application.

India's original growth spurt in agricultural output, enabling it to become self-sufficient in spite of a population that more than tripled since independence – the so-called 'Green Revolution' – was achieved by adopting new varieties of crop and by widespread use of fertilizer via subsidy schemes. Production of fertilizers – especially urea - was subsidised for manufacturers, and use of them subsidised for farmers. The subsidy scheme led to a large number of urea plants being developed in the country, but there have been concerns that nitrogen – especially urea – has been promoted at the expense of other nutrients like phosphorus and potassium. Previous governments have tried to ameliorate this by decontrol of prices and fixing the manufacturing subsidy on a nutrient basis. However, urea has so far fallen outside the existing nutrient based subsidy (NBS) scheme, and continues to be sold in India at a government-set price under a separately-administered scheme. The government also continues to reimburses urea producers under the old subsidy scheme. at the cost of production plus a 12% return on net worth. The fixed price for urea is currently 5,360 rupees per tonne and the government subsidy rate rupees 11,760 per tonne. This advantages urea price-wise compared to other fertilizers, and has had the opposite effect that the NBS intended, leading to a distortion away from the 'ideal' NPK application ratio of 4:2:1 to something closer to 8:3:1. This in turn has had a knock-on effect on farming yields.

Meanwhile, the cost of producing fertilizers domestically in India has risen. India's urea production relied as feedstock originally mainly on naphtha, fuel oil, and a couple of coal gasification-based plants. The soaring cost of oil and naphtha during the 1990s led to a move to base production on natural gas instead, but as India moved towards gas-based power production, so gas prices also rose, and so did the subsidy budget. This led to a freeze on new urea plant construction from the mid-1990s, which in effect remains in place today. At the time that the Modi government took power, there were 27 urea plants operating in India with a total capacity of 21.25 million t/a, many of considerable vintage (see Table 1), and in the meantime India has run a growing deficit in urea made up for with imports, which have soared to 6.6 million t/a. If consumption continues to increase to meet new targets for food security, this will increase still further.

In summary, then, India faces a complex series of challenges. In order to meet the grain demand set out the National Food Security Bill, the crop productivity of India's farm land has to rise. Among other things, this requires greater application and consumption of plant nutrients based on the right assessment of soil fertility; the current fertilizer consumption of 140Kg/ha is still relatively low compared to developed countries. However, this also needs to be more balanced in order to ensure a stable and sustainable soil NPK ratio. But India is even so already the world's largest importer of N, P and K fertilizers.

Table 1: **Indian urea capacity** 2013

Company	Location	Nameplate capacity, t/a
Public Sector		
Brahmaputra Valley Fertilizer Co Ltd	Namrup-II	240,000
Brahmaputra Valley Fertilizer Co Ltd	Namrup-III	315,000
Madras Fertilizers Ltd	Chennai	486,000
National Fertilizers Ltd	Bhatinda	512,000
National Fertilizers Ltd	Nangal-II	478,000
National Fertilizers Ltd	Panipat	512,000
National Fertilizers Ltd	Vijaipur-I	865,000
National Fertilizers Ltd	Vijaipur-II	865,000
Rashtriya Chemical and Fertilizers Ltd	Thal	1,706,000
Rashtriya Chemical and Fertilizers Ltd	Trombay-V	330,000
Total (Public Sector)		**6,309,000**
Co-Operative Sector		
Indian Farmers Fertilizer Cooperative	Aonla-I	865,000
Indian Farmers Fertilizer Cooperative	Aonla-II	865,000
Indian Farmers Fertilizer Cooperative	Kalol	545,000
Indian Farmers Fertilizer Cooperative	Phulpur	550,000
Indian Farmers Fertilizer Cooperative	Phulpur II	865,000
Krishak Bharati Cooperative	Hazira	1,730,000
Total (Co-Operative Sector)		**5,420,000**
Private Sector		
Coromandel Fertilizers and Chemicals Ltd	Gadepan-I	865,000
Coromandel Fertilizers and Chemicals Ltd	Gadepan-II	865,000
Gujarat Narmada Valley Fertilizers	Bharuch	636,000
Gujarat State Fertilizer & Chemicals Ltd	Vadodara	370,000
Indo-Gulf Fertilizers	Jagdishpur	865,000
Kribhco Shyam Fertilizers Ltd	Shahjahanpur	865,000
Mangalore Chemicals and Fertilizers	Mangalore	380,000
Nagarjuna Fertilizers & Chemicals Ltd	Kakinada-I	600,000
Nagarjuna Fertilizers & Chemicals Ltd	Kakinada-II	600,000
Shriram Fertilizers and Chemicals	Kota	379,000
Southern Petrochemcial Industry Co	Tuticorin	620,000
Tata Chemicals Ltd	Babrala	865,000
Zuari Agro-Chemicals Ltd	Goa	400,000
Total (Private Sector)		**8,310,000**
Grand Total		**20,040,000**

Source: Government of India

Policy measures

As detailed by Dr M.P. Sukumaran Nair in our sister publication *Fertilizer International* (issue 465, March-April 2015), the new government has come up with the following multi-pronged strategy to tackle these challenges:

- Increase domestic urea production. The government has developed a policy to promote new investment in brownfield and greenfield plants to address India's growing import burden. However, extra investment has failed to materialise so far, despite a series of modifications to urea investment policy over the past few years, with the supply of natural gas remaining a major hurdle. The shortfall in anticipated gas production from the new Krishna Godavari (KG) fields and increases in liquefied natural gas (LNG) costs have largely counteracted government incentives to produce more urea.
- Improve balanced use of nutrients. The government is planning a massive programme for testing the soil nutrient requirements of farm land in order to achieve more careful application of fertilizers. The recent budget included a proposal to distribute soil health cards to farmers. However, the continuing exclusion of urea from the nutrient based subsidy scheme continues to work against this.
- Adopt a more balanced import programme. In response to increasing fertilizer consumption, rising imports and a large outflow of foreign exchange, the government has adopted a three-fold approach, involving encouraging domestic producers to enter into long-term supply contracts with foreign suppliers, set up joint ventures with overseas producers and buy-up fertilizer assets abroad. There has already been some success in this field with the Oman-India Fertilizer Company (Omifco) on the urea side and various joint venture companies in the phosphate field.
- Addressing manipulation of the subsidy system. Fertilizer producers are paid subsidies based on the quantities they send to the market, but instances of large-scale manipulation of this system have been observed. To overcome this, the government is upgrading information technology to allow national rollout of a new system of direct transfer of subsidy payments to farmers.

Feedstock – coal

Shortage of natural gas is the main hurdle for expanding domestic nitrogen capacity. China, facing a similar situation with regard to gas, built ammonia and urea plants based on coal gasification which by and large operate economically. India has some experience of operating coal-based ammonia plants at Ramagundam and Talcher, but technical issues led to those plants being closed down many years ago. Nevertheless, coal gasification technology has moved on since then and offers the prospect of India repeating China's success in this regard. However, the actual execution of this has not always been a smooth process, with the two major development projects facing issues over the allocation of coal supplies. Finally, however, the Talcher project in Odisha state

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

seems to be moving forward. Coal India Ltd is working with the Gas Association of India Ltd (GAIL), the Fertilizer Corporation of India Ltd – which operated the two original coal-fired plants – and Rashtriya Chemicals and Fertilizers (RCF). Coal India and GAIL are developing the $840 million upstream coal gasification plant and RCF is working with CIL on the downstream ammonia, urea, nitric acid and AN plants. Capacities at the complex are to be 2,700 t/d of ammonia, 3,850 t/d of urea, 850 t/d of nitric acid and 1,000 t/d of ammonium nitrate. Construction is likely to start in the 2015-16 financial year (beginning April 2015) according to the partners, after preparation of a detailed feasibility study, and is expected to be complete by the end of 2019. Hansraj Ahir, India's Minister of State for Fertilizers and Chemicals, has indicated that the government is considering 10 new coal-based urea plants in coal rich states of the country such as Chhatisgarh, Jharkhand, Bihar, West Bengal, Maharashtra, Uttar Pradesh and others where coal is available in large quantities.

Natural gas

Meanwhile, although the fertilizer industry enjoys priority allocation of natural gas, the decline in production from domestic gas fields and the relatively high cost of LNG makes developing new gas-based ammonia-urea capacity difficult. The government has therefore tried to tackle natural gas price reform in order to encourage higher prices and further drilling. The old fixed gas price of $4.20/MMBtu has been raised to $5.60/MMBtu, although offshore gas producers charge up to $8.00/MMBtu, and LNG often comes in higher than that. The government has also agreed that urea plants will be charged at a uniform price for gas via a pooling mechanism, regardless of where the gas has come from. The measure is expected to help in reviving the Gorakhpur, Barauni and Sindri urea plants on the Jagdishpur-Phulpur-Haldia (JPH) pipeline. As a result, work on this pipeline which was approved in 2007 is now finally expected to start this year. The Department of Fertilizer has estimated that the decision will lead to the additional production of around 370,000 t/a of urea in existing units over the next four years.

The import of additional LNG is also being explored as a way of increasing gas availability. There are currently, four LNG terminals in India: Dehej and Hazira in Gujarat; Dabhol in Maharashtra; and Cochin in Kerala, and others are planned on the east and west coasts, but apart from Dahej none are currently running at capacity due to a lack of viable long-term supply contracts and distortions in the pricing of domestically-produced natural gas versus regasified LNG. There is now a move to tackle this.

There has also been some progress with developing coalbed methane production, and the world's first urea plant based on coal bed methane is being built by Matix Fertilisers and Chemicals in Panagarh, West Bengal. Construction is close to completion, although the supply of feedstock from the Raniganj coalfields has yet to be fully established, and illustrates the problems that policy indecisiveness can cause for those contemplating large investments in the sector.

Finally, the remaining three naphtha-based plants have been told that they will receive no further subsidy beyond April, although there has been a plea to allow them to continue until a switch to using natural gas feedstock is completed in a couple of years time.

> “The key issue will be in providing sufficient feedstock for these plants.

Future outlook

The government was widely expected to increase urea prices in the 2015-16 budget, but in the end ducked away from this, worried about votes from rural regions which would bear the burden of cost increases. However, until there is a decontrol in urea prices, India will effectively continue to over-apply urea at the expense of phosphate and potassium fertilizers, and the government's goal of balancing nutrient use will remain out of reach. The move towards switching subsidies directly to farmers offers the promise of squaring this circle, however, and the government has begun by opening bank accounts for 115 million people to receive the subsidies. Likewise the Soil Health Card scheme which began in February and which will provide the results of nutrient testing of soils to 140 million farmers over the next three years will help educate and inform farmers and help the government develop better policy solutions and allocation of resources for investment in areas such as irrigation and other inputs such as slow-release urea.

In the meantime, however, there is a concerted effort to simply up domestic production of urea from its present 23 million t/a towards a demand that is rising past 30 million t/a. The government hopes to encourage up to 10 million t/a of extra production over the next five years, in theory turning India from the world's largest importer of urea into a net exporter, similar to the transformation that China made during the 1990s. There are five urea plants that are slated for revival and expansion, including the coal-based expansion at Talcher. The government is also targeting new plants with Rashtriya Chemicals and Fertiliers developing a project at Thal in Maharashtra and by BVFCL in Assam, and new plants in Madhya Pradesh and Karnataka.

The key issue will be in providing sufficient feedstock for these plants. Neighbouring Pakistan has shown that it is one thing to build urea plants, but quite another to have sufficient natural gas to operate them, especially when rainfall is low and power output from hydroelectric plants down and the power industry needs to switch to gas-fired power production. The rises in Indian domestic gas prices may help this and encourage new production, and there is no doubt that the fall in global LNG prices as oil prices come down has also been a useful boost to India.

Nevertheless, all of this urea will ultimately be based on government subsidy, to producers to pay for feedstock, and to farmers in order to purchase it. India already spends about 2% of its GDP on subsidies to the energy, fertilizer and agricultural sectors, and this seems only set to increase for the time being. The new budget raised fertilizer subsidies by 2.8% for 2015-16, most of that increase aimed at potassium and phosphate fertilizers. Additional money was set aside for urea imports as well. But there remains a major issue of unpaid subsidy payments to producers which has built up year by year as the government clears its current bills but leaves previous payments still pending. In spite of some special banking arrangements for the industry the problem persists and is another issue that the government has not yet managed to tackle. ■

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Urea barges on the Mississippi River.

Changes in the global market for urea

A look at the major trends shaping the market for the world's most popular nitrogen fertilizer.

Just as nitrogen is the most required plant nutrient, so urea is its major method of delivery, being high analysis (46% nitrogen by weight), easily transportable, and easy to apply in developing countries where more sophisticated liquid-based delivery systems are unavailable. It is also not subject to the same shipping, handling and storage regulations which have restricted ammonia and ammonium nitrate's use as a fertilizer. IFA calculate that 55% of all nitrogen application worldwide is as a fertilizer, and fertilizer uses represent more than 80% of all urea consumption.

On the demand side, then, urea consumption depends on agricultural markets, and in particular grain markets, which are not only some of the largest in terms of tonnages, but which also require proportionately more nitrogen than some other types of crop. Global grain and oilseed consumption has grown at a rate of about 2.5% over the past decade, and there has been an increase in cropped area (in places like Brazil and North America) driven by strong demand and high crop prices – crop prices have declined over the past couple of years, but still remain broadly supportive of increased fertilizer application. And although stock: use ratios have been increasing from their low point a few years ago, they remain low by historical levels. Extreme weather events (droughts, delayed monsoons etc) have also played a part in making yields occasionally variable in spite of increased inputs.

Table 1 ranks major countries in terms of their consumption of urea (treating the EU as one whole). Net importers are shown in bold. As can be seen, China and south Asia (especially India) dominate consumption, with China representing 35% of demand and south Asia 23% (of which India is 18%), followed by North America (9%) and Europe (7%). These four regions are 75% of all urea consumption between them. Other major consuming regions are South America (especially Brazil) and southeast Asia. However, while most of these major consumers are also major importers of urea, China stands out as a major exporter. The other main exporting countries are Russia and Ukraine, and the countries of the Middle East and Arabian Gulf – Egypt, Saudi Arabia, Qatar, Oman and Iran.

Internationally traded urea represents about 26% of all urea, perhaps a surprisingly small volume compared to some commodities. This is mostly because the largest consumers, India and China, have traditionally maintained a policy of self-sufficiency or near-self sufficiency in urea production.

China

China worked hard at achieving self-sufficiency in urea production during the 1990s and 2000s, and over the past few years capacity has moved in excess of demand, turning the country into a large net exporter. Indeed, in 2014 China exported 13.6 million tonnes of urea, significantly more than the 8.3 million tonnes exported in 2013. There was also 4.4 million tonnes exported in the first quarter of 2015.

Chinese urea output is mainly based on ammonia derived from coal feedstock. There was a push for gas-based capacity in the late 1990s, when plants such as Henan Island were built, but shortages of gas – required for power production – and an abundance of coal has led to the concentration on coal-based capacity.

Because Chinese domestic prices for urea were subsidised and producers could often get greater margins overseas, for a while China maintained a policy of trying to control urea exports during peak application season via punitive export tariffs. However, the abundance of urea on the domestic market and slow liberalisation of internal pricing has led to these tariffs being relaxed now, another reason for China's spurt in export growth.

Furthermore, the slow-down in the Chinese economy has led to coal prices falling, and Chinese ammonia-urea producers with newer plants have also switched away from more expensive anthracite towards powdered coal or lower grade bituminous feedstocks, again reducing their production costs. Others are based around coke oven gas, have profitable methanol side-streams, or are otherwise integrated into power/energy production. Thus while there are still a large number of older, less efficient ammonia-urea units in the country, many Chinese plants are able to operate profitably in the $270/t f.o.b. region in terms of urea prices, and China has in effect become the floor price setter in the urea market and the swing producer – which until a couple of years ago was a position held by Ukraine.

China continues to build new urea capacity. The China National Chemical Information Centre estimates another 4.5 million t/a of capacity will come on-stream in the second half of 2015 alone, although around 4 million t/a of closures of older, less efficient capacity is also expected. Nevertheless, somewhere in the region of 20 million t/a of new capacity is expected by the end of the decade in China in spite of a block by central government on new gas and anthracite-based capacity and a minimum plant size stipulation of 1,000 t/d of urea.

> “China has in effect become the floor price setter in the urea market.”

India and south Asia

India's urea market is dealt with in greater detail elsewhere in this issue (pp24-27), and like China is heavily dependent on government policy. South Asia in general has tried to maintain self-sufficiency in urea in the same way that China has, but has a similar issue with shortages of natural gas, and so far has not managed to switch to coal-based production in the same way that China has, although there are signs that this may be changing now, in India at least. As a result, there has been no new urea plants built in India for 20 years, and those completed in Bangladesh and Pakistan face a scramble for natural gas supply allocations, competing with power producers. Consequently, south Asia is now the major importing region for urea, as Table 1 shows, attracting over 20% of all traded urea. As our India article discusses, the Indian urea market is in a state of flux at the moment with the government trying to rein in its subsidy regime and encourage new capacity, with coal now very much on the agenda, but in spite of a couple of new plants (one of which, based on coalbed methane, is due to be completed soon), south Asia is likely to remain a large net importer of urea for the foreseeable future.

Table 1: **Major urea suppliers and consumers, 2013,** million tonnes N

Country	Consumption (tN/a)	Production (tN/a)	Net imports (tN/a)
China	27.5	31.3	- 3.8
India	**14.2**	**10.6**	**+ 3.5**
USA	**5.6**	**2.9**	**+ 2.6**
EU-28	**5.6**	**4.5**	**+ 1.2**
Pakistan	**2.8**	**2.2**	**+ 0.5**
Brazil	**2.4**	**0.6**	**+ 1.8**
Indonesia	2.5	3.0	- 0.5
Canada	1.4	1.6	- 0.2
Vietnam	**1.2**	**1.0**	**+ 0.2**
Thailand	**1.1**	**0**	**+ 1.1**
Bangladesh	**1.0**	**0.6**	**+ 0.4**
Egypt	0.9	1.8	- 0.9
Iran	0.8	1.8	- 1.0
Russia	0.5	2.9	- 2.3
Ukraine	0.2	1.3	- 1.1
Saudi Arabia	0.1	1.5	- 1.4
Qatar	0	2.5	- 2.5
Oman	0	1.6	- 1.6
Others	10.1	6.2	
World total	**77.9**	**77.9**	**(20.6)**

Source: IFA

North America

The situation in North America is being transformed by increased production of shale gas. Previously the US had become too expensive for gas-based ammonia capacity, and had instead turned to imports – from Trinidad for ammonia, and from Canada, Venezuela, even the former Soviet Union for urea, leading to the US becoming the second largest importer of urea, as shown in Table 1. Now however there are dozens of new ammonia-urea projects under development hoping to take advantage of cheap shale gas, and even if only a handful of these make it to completion, this seems set to turn around the situation for the US. While it is unlikely to become completely self-sufficient in urea, its import requirements are certainly set to drop over the next few years, with, e.g. two new plants completed for CF Industries in 2016 and 2017.

Europe

Europe continues to be a major net importer, as much of the continent's domestic fertilizer production has been forced into closure by rising natural gas prices which have made it uncompetitive with imports

■ CONTENTS
What's in issue 335
■ COVER FEATURE 1
Urea markets
■ COVER FEATURE 2
India's subsidy policy
■ COVER FEATURE 3
CO_2 in methanol production
■ COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

from cheaper locations abroad. Although Europe makes extensive use of ammonium nitrate as a nitrogen fertilizer, the countries of southern Europe are also major urea consumers. Europe's imports come mainly from North Africa and the FSU, with some also coming from as far afield as the Middle East. Europe also makes extensive used of non-fertilizer urea for industrial or so-called 'technical' uses.

South America

The expansion of agriculture into Brazil's *cerrado* region has been one of the major stories of the past few years, leading to a major boost in fertilizer demand. There has been some attempt to develop nitrogen capacity in the region, using gas imported across the Andes from Peru, but at the moment the increasing urea consumption in Brazil is mainly being fed from extra imports from overseas. Brazil is now the world's third largest importer of urea, as Table 1 shows.

FSU

Traditionally one of the major exporters of urea, there are a number of export-oriented plants which sell either via Black Sea ports or the Baltic Sea. However, the price of gas paid by Ukrainian producers has risen to very high levels, and gas supplies were frequently cut off due to disputes with Russia's Gazprom even before the Ukrainian crisis blew up last year. Now the fighting in the east of the country has shut down Severodonetsk on what looks to be a permanent basis and closed Stirol for several months. Elsewhere in the region, landlocked countries with natural gas to spare like Azerbaijan, Kazakhstan and Tajikistan have all looked to urea as a possible way of easily monetising those reserves.

Middle East/North Africa

As Table 1 shows, the countries of North Africa and the Arabian Gulf are generally not major consumers of urea and instead have used cheap and abundant local supplies of natural gas to develop export-oriented capacity. In North Africa, Algeria and to a lesser extent Libya became major exporters of ammonia, and Egypt of urea. But rising domestic demand and gas supply issues in Egypt and the civil war in Libya have reduced output from these locations, and now only Algeria developing new capacity. In the Arabian Gulf, Saudi Arabia, Qatar, Oman and Iran are all major exporters of urea – in Iran's case in spite of the US sanctions regime, as it has been able to supply to India. Oman's capacity has been developed with Indian partners and is also aimed at the Indian market. The Arabian Gulf was for much of the 2000s the main place to build new export-oriented capacity, and there are still new developments there, such as the Safco V plant and the second Ruwais unit which recently started up, but gas is becoming more expensive and more difficult to get hold of in the region, and only Iran – if the deal over uranium enrichment sticks – has the real prospect of much more capacity; several large plants have been under development for some years there.

Table 2: **Urea supply additions up to 2019**

Region	**Urea capacity increase (million tonnes)**
Middle East	1.1
Southeast Asia	1.9
South Asia	1.9
Latin America	3.3
CIS	4.2
Africa	4.4
North America	5.0
China	14.5
Total	**36.3**

Source: CRU

Southeast Asia

Southeast Asia has some major consumers, such as Thailand and Vietnam, as well as significant producers such as Indonesia and Malaysia. Vietnam was one of the world's largest importers of urea until it moved forward with a self-sufficiency policy based on both coal and gas-based capacity which has effectively wiped out that deficit. Indonesian exports meanwhile have fallen due to gas supply constraints in some parts of the country and Chinese-style export bans designed to make sure urea goes to local, subsidised farmers.

New supply

Because urea is fairly easily and cheaply transported by dry bulk shipping, the tendency has been for capacity to gravitate towards cheaper gas locations from where the urea can be shipped to major markets, balanced by self-sufficiency policies in major consuming nations like India, China and Vietnam. Table 2 shows that about 36 million t a of new urea capacity is planned for commissioning over the 2015-19 period. The rate of capacity growth this decade has been higher than for any decade previously. While China represents about 40% of capacity additions, the spread of new capacity is otherwise much more even than it has been in previous capacity building cycles, with the US, Brazil, India, Indonesia, Saudi Arabia and Vietnam all developing new projects. There are also more speculative projects being built in Nigeria and elsewhere in Africa, potentially the last real source of 'stranded' gas left in the world. Some of these have run into trouble – Brazil in particular has not been able to move ahead as quickly as it would like with new projects.

However, it seems clear that even if this new supply figure is over-optimistic, it is likely to run well in excess of demand, which may improve by only 15-20 million t/a over the same period. This points to an excess going forward, and while there may be gas supply issues in some parts of the world and regional security issues in other, the prospect of major new capacity building in the largest import markets like India and the US means that urea prices may well fall towards a floor driven by production costs in the marginal producer – in this case China. Chinese urea exports, conversely, continue to increase. Some have suggested that they could reach 17.5 million t/a in 2015, up 30% even on 2014's record figure.

China the key

Chinese factory gate prices for most coal-based producers are currently put in the region of \$220/t, with port prices rising to \$290-295/t f.o.b. once export taxes are included. If this is higher than the \$270s and even \$260s/t which have been seen recently, then it indicates that a number of Chinese producers are not running at profitable levels, and that these are prices which are unlikely to be maintained in the longer term. It has also bee suggested that rising labour and freight costs in China, a tightening coal market and the appreciation of the remnimbi may conspire to force Chinese floor prices still higher over the next few years. ■

CONTENTS
What's in issue 335

COVER FEATURE 1
Urea markets

COVER FEATURE 2
India's subsidy policy

COVER FEATURE 3
CO_2 in methanol production

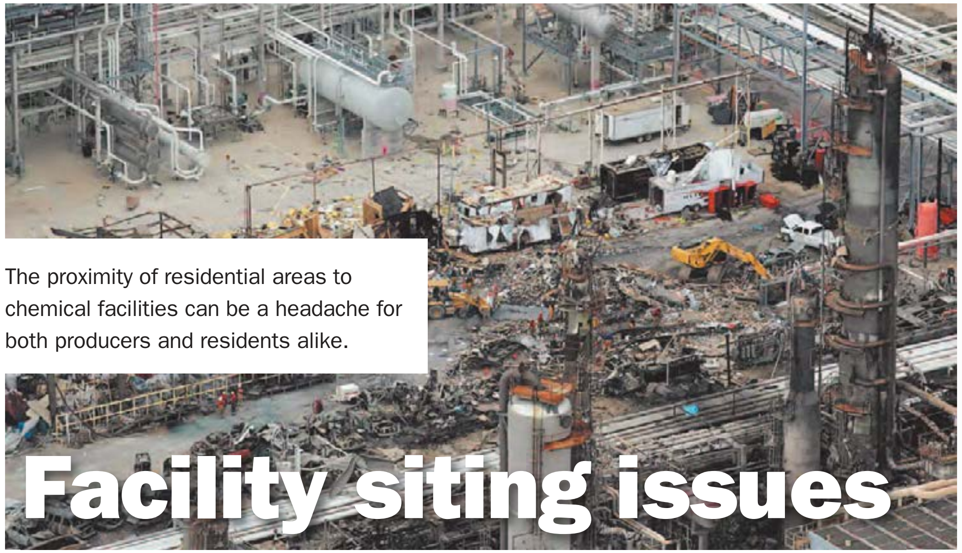
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31



Facility siting issues

The proximity of residential areas to chemical facilities can be a headache for both producers and residents alike.

The manufacture and storage of hazardous chemicals in the vicinity of residential areas is a particularly vexed area for the nitrogen industry, covering as it does the manufacture of ammonia, which can form a toxic gas cloud at normal temperatures and pressures, and ammonium nitrate, which under the wrong circumstances can be a fire accelerant or even in extreme cases the source of an explosion. The fire and subsequent explosion at the West Fertilizer Company in West Texas in which 15 people were killed illustrated the potential dangers of storage of such chemicals in the vicinity of residential areas, and as bad as the accident was, the consequences could have been far worse if the nearby school – less than 1km from the seat of the explosion - had been occupied at the time.

There were echoes of the September 2001 explosion at the AZF facility at Toulouse in which 29 died and 2,500 were injured, with thousands of homes damaged, where again stored AN in the proximity to built-up areas was the issue. The potential release of an ammonia cloud was also a concern at West – indeed it was the reason why the firefighters who died were so close to the blaze. One of the first articles that I wrote for *Nitrogen* magazine (as it was then) concerned a 1995 US Environmental Protection Agency-sponsored study into the large scale storage of anhydrous ammonia at the terminals at Tampa Bay[1], and modelling of the potential consequences of a release (*Nitrogen 217*, Sept/Oct 1995, pp15-21), while the presence of a large ammonia storage tank owned by Haifa Chemicals at the Israeli port city of Haifa has been a bone of contention there for several years and has led to a recent change in government policy to develop ammonia production in the south of the country to allow storage at Haifa to be run down. Releases and leaks from some nitrogen plants have led to shutdowns and public anger in places as far afield as Argentina and Australia.

All of these incidents and concerns share a common thread, which is that while these facilities may have been a long way from populated areas when originally conceived and built, the gradual encroachment of residential areas has brought the public within the potential danger zone. This is of course not necessarily any fault of the chemical companies concerned, and instead is often the result of laxity of local civic planning authorities or lack of coordination between them and the facility concerned, but once the collision between facility siting and public safety occurs, local authorities perhaps understandably tend to be minded to close down, move on or restrict the chemical facility rather than demolish homes.

Siting requirements

A further impetus to chemical facility siting issues came in the US following the explosion at the BP America Texas City refinery in 2005. The US Chemical Safety Board (CSB) picks a couple of major incidents every year to investigate in depth and provide detailed safety guidelines and recommendations on, and chose the Texas City incident for 2006 – the final report on the accident was published in 2007. In parallel the CSB recommended that BP commission an independent panel to investigate the safety culture and management systems at BP North America. This panel, led by former secretary of state James Baker, also reported in early 2007.

The CSB and Baker Reports tackled a wide range of issues, from risk management to safety culture, but also included facility siting issues, one of which at Texas City was a series of temporary buildings on-site which had not been part of previous risk planning procedures and where a number of the deaths and injuries had occurred. Johnson Matthey used the report as a jumping off point for an internal review of their own safety procedures, and presented the results at the 2009 AIChE Ammonia Safety Symposium[2], and risk management specialists Baker Risk also presented a review of facility siting in ammonia plants at the same meeting based on expected revisions to existing guidelines as a result of the CSB report[3].

RP-752

In the US, the widely recognised practice for complying with facility safety requirements is the American Petroleum Institute (API) Recommended Practice (RP)-752 facility siting requirements, which "provides guidance for managing the risk from explosions, fires and toxic material releases to on-site personnel located in new and existing buildings intended for occupancy". Temporary and portable buildings are covered by a separate API recommended practice, RP-753. The result of the CSB and Baker Reports on Texas City was a review of RP-572 which led to the 3rd Edition, "Management of Hazards Associated with Process Plant Permanent Buildings", published in 2009.

The 3rd edition was a substantial change from the 2nd, and rather than a technical manual full of building damage correlations, generic explosion frequencies and occupant vulnerability, it became a management process for facility siting evaluations. As Baker Risk put it in their review of the document[4]; "facility siting is no longer viewed as a one-time event; rather, facility siting is treated as an on-going process."

A siting evaluation includes identifying buildings included in the evaluation. A major change in RP-752 was disallowing occupancy screening, shown by example in prior editions, based on man-hour occupancy surveys. Occupancy is now decided based on building function. If a building is "intended for occupancy," it is now included within the scope of a facility siting evaluation regardless of the number of man-hours of occupancy. Any buildings with personnel assigned or used for recurring group functions are deemed "intended for occupancy."

Either consequence-based or risk-based analysis methods may be used for the evaluation. Risk assessments must be quantitative and include consideration of group risk for all occupants of a building. Consequence-based methods must use "maximum credible events" as the evaluation cases, which are specific to individual buildings, and may be separate scenarios for explosion, fire, and toxic hazards. RP-752 does not recommend the size or magnitude of scenario to use, but indicates that MCEs have the maximum consequence among the major scenarios considered, and include consideration of company and industry experience.

Different approaches may be used for explosion, fire, and toxic analyses; for example, risk criteria may be used for explosion, consequence criteria for toxics, and spacing tables for fire. The results of the siting evaluation consequence or risk analyses are compared to the criteria. For any instances when a building does not meet the criteria, a mitigation plan is required. The mitigation plan is required to contain action items, and very importantly, schedules. RP-752 includes a listing of potential mitigation options, which are prioritized to favour inherently safer methodologies. Passive mitigation is given highest preference and administrative controls are given lowest preference.

Zoning issues

However, while RP-752 and -753 are clear for actions to be taken by companies within a site in order to safeguard the lives of employees, contractors and visitors, the division of responsibility between company and local authority is not always a well delineated one when it comes to considering protection of life and property around the facility, as was painfully shown by the accident at West in 2013. The fact that a middle school and nursing home were allowed to be located so close to a facility storing ammonia and ammonium nitrate is a clear concern. Local planning and zoning officials evidently often do not have critical information such as downwind hazard zones or isolation protective action distances during the planning board process.

The CSB has picked West as one of its major accident investigations, and while it has yet to publish a final report on the incident, one is expected in the next few months. In a press statement last year, director Rafael Moure-Eraso gave a hint as to some of the thinking of the CSB. He has formally recommended that OSHA and the US Environmental Protection Agency (EPA) begin rulemaking on reactive chemicals, and that the EPA strengthen its Risk Management Programme, which is specifically designed to protect the public from chemical disasters but which does not list ammonium nitrate as one of the chemicals it covers. The CSB's supervisory investigator, Johnnie Banks, added that their findings showed that "there is a patchwork of federal and state regulations with huge gaps that allowed this incident to happen." The Department of Homeland Security, for example, which is meant to monitor explosives and precursors, did not even know that there was AN being stored at West. And while some of these gaps covered fire codes, emergency planning responses and the application of the OSHA Explosive and Blasting Agents Standard, according to Banks the CSB has also identified "at all levels of government a failure to adopt codes to keep populated areas away from hazardous facilities."

The explosives industry uses physical separation between explosive hazards and occupied buildings as an effective mitigation technique. The American Table of Distances for Storage of Explosive Materials, published by the Institute of Makers of Explosives (IME, 1991), provides guidance on the safe separation of explosive hazards from inhabited buildings. It is clear that these were not applied at West.

The US has no national/federal body responsible for these kind of zoning decisions, which are left to local planning authorities who often do not have the specialist knowledge or expertise to properly evaluate these kind of hazards when permitting new housing developments, and the same is true of the UK and many other countries. Considering that companies involved in chemical manufacture and storage often have to conduct extensive risk management assessments of their own site and their potential impact on the surrounding area, it seems clear that there has to be come kind of joined-up decision making in order to ensure that local planning authorities are able to draw on this expertise and perhaps third party assistance from elsewhere in setting safety zones around facilities in which new construction is not permitted. How this circle is squared may be one of the most important findings of the CSB report on West. ■

References

1. 'Safe Enough?' *Nitrogen 217*, Sept/Oct 1995, pp15-21.
2. Lynas C, Campbell E, Koornhof H, Johnson Matthey Catalysts – The Baker Report: how findings have been used by Johnson Matthey to review their manufacturing operations. Paper presented at AIChE Ammonia Safety Symposium, September 2009.
3. Baker Q, Dejmek, K, Qin, X, Baker Risk – *Facility Siting In Ammonia Facilities*. Paper presented at AIChE Ammonia Safety Symposium, September 2009.
4. Baker Risk Bulletin, Vol 16, issue 1, May 2010.

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

CO_2 in methanol production

Capital cost is the single biggest input into the economic feasibility of a large methanol project. However, with the increased concerns on the effect of CO_2 emissions, operating efficiency and CO_2 emissions are an increasingly important factor.

For natural gas based methanol plants, typical options available for synthesis gas production are steam methane reforming (SMR) and SMR followed by oxygen blown autothermal reforming (ATR).

SMR-based synthesis gas production is normally used for methanol plant capacities up to 2,500 t/d. The SMR followed by oxygen-blown ATR option is normally used for plant capacities greater than 2500 t/d.

With global demand for methanol expected to continue to steadily grow, methanol plants exceeding 5,000 t/d are being designed and constructed to take advantage of the economy of scale. Standalone ATR technology is already a well-proven solution for large syngas units in GTL plants and is being developed for large-scale methanol synthesis. Benefits of standalone ATR include:

- production of syngas with high CO/CO_2 ratios, which results in higher methanol reaction rates
- low steam requirements, which lead to lower capex and opex in large methanol plants
- low steam throughput, which enables larger single-line capacity.

The synthesis gas from SMR is generated from natural gas (comprising mainly methane) according to the following reactions:

$$CH_4 + H_2O = CO + 3H_2$$

$$CO + H_2O = CO_2 + H_2$$

Depending on the outlet gas pressure and temperature, and the inlet steam to carbon ratio, a specific composition of hydrogen, carbon monoxide, carbon dioxide and methane is produced. The so-called stoichiometric number (SN) or gas module (M), defined according to the following formula, is then used to indicate how suitable the gas composition is for the methanol synthesis reactions:

$$SN = (H_2 - CO_2) / (CO + CO_2)$$

The optimum SN for the following methanol reactions is usually around 2.05; whereas, the theoretical SN for the syngas generated from an SMR is 3.

$$CO + 2H_2 = CH_3OH$$

$$CO_2 + 3H_2 = CH_3OH + H_2O$$

$$CO + H_2O = CO_2 + H_2$$

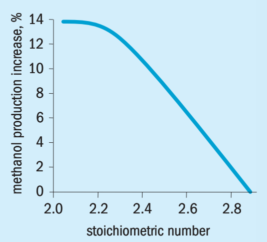
In practice, considering the inert gases in natural gas and unconverted methane in the SMR exit gas, the SN is typically around 2.9. This is far from optimal to produce methanol effectively. The consequence is poor performance of the synthesis process and high carbon dioxide emissions from the plant.

When this ratio is decreased to 2.05 through the injection of CO_2 (captured from the SMR flue gas or from an outside supplier); the hydrogen usage efficiency increases in the methanol synthesis loop resulting in an increase in the methanol production. This means both lower natural gas consumption and lower emissions from the SMR furnace per tonne of methanol produced.

Advantages of recovering CO_2 from the SMR flue gas are:

- cost certainty (i.e. control of source, quality and quantity of CO_2)
- no pipeline or rail/road transportation required
- carbon footprint reduction.

Fig 1: **Increase of methanol plant production – 48% CO_2 injected**



Source: Topsoe

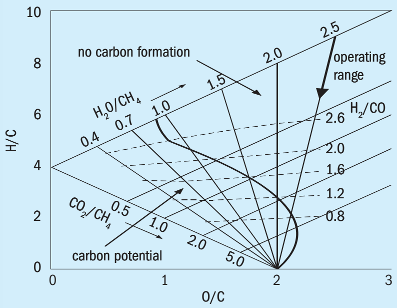
The captured carbon dioxide can be injected into the SMR inlet or outlet gas. Both scenarios improve the SN for methanol production.

The graph in Fig. 1 shows how the production rate of a typical methanol plant can be increased by injecting about 48% of carbon dioxide from the SMR flue gas to the syngas. Carbon dioxide injection to the syngas lowers the SN from 2.9 to 2, resulting in about 14% increase in production. The carbon footprint, by adopting this process scheme, would be reduced by almost half.

Topsoe experience in CO_2 reforming

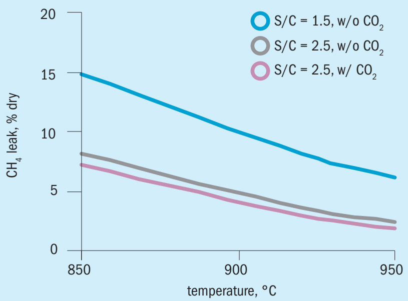
Reforming of methane with mixtures of steam and carbon dioxide ("carbon dioxide reforming") or with carbon dioxide alone ("dry methane reforming", DMR) has been the focus of increased attention as it in theory offers a way of using CO_2, which in many industries is considered as a waste product and environmentally is considered as a polluting greenhouse gas. However, when considering the use of CO_2 in reforming it should be recognised that the potential impact on CO_2 emissions is not very significant. For example, if all carbon in the yearly methanol demand of close to 65 million t/a in 2013 was assumed to come from CO_2, a net capture of 89.3 million tons/year could be achieved. Comparing this figure to the annual CO_2 emission of 34,500 million tonnes in 2012 shows that it would only correspond to a 0.26% reduction in CO_2 emissions. CO_2 reforming or DMR related to the production of chemicals should therefore not be seen as a route for greenhouse gas reduction, as the problem is too big, but rather as a mean to process hydrocarbon feeds with high CO_2 contents or processing of inexpensive CO_2 (waste) streams.

Fig 2: **Carbon limit of equilibrated syngas at 25 bar**



Source: Topsoe

Fig 3: **Reformer methane slip at 25 bar**



Source: Topsoe

CO_2 for large scale methanol plants

In contrast to steam reforming of natural gas, addition of CO_2 permits optimisation of the synthesis gas composition for methanol production. In addition, CO_2 constitutes a less expensive feedstock and CO_2 emission to the environment is reduced. CO_2 is also easier to reform than natural gas, leading to energy and investment savings under the right circumstances.

However, the import of CO_2 may necessitate compression and purification of an extra feedstock, thus adding extra unit operations to the plant. Therefore, CO_2 reforming only makes good economic sense for large-scale methanol plants when a large and relatively pure amount of CO_2 is available free of charge.

Besides the advantages of CO_2 reforming there are certain constraints with respect to the amount of CO_2 which can be added. These constraints include mass balance, kinetic and thermodynamic limitations.

Mass balance constraints

Syngas is in balance for the methanol reaction when the SN is equal to 2. Steam reforming of methane produces an excess of hydrogen. This excess of hydrogen permits a certain import of CO_2. As visualised by the reaction below, it can be proven that a SN of 2 is reached with a CO_2 import corresponding to a CO_2/CH_4 ratio in the reformer feed of 1:3.

$$3CH_4 + CO_2 + 2H_2O = 8H_2 + 4CO \quad (SN=2)$$

In the real world, natural gas feedstocks contain higher hydrocarbons as well as CH_4. In this case, a module of 2 is reached with a CO_2 import corresponding to a $CO_2/C_nH_{(2n+2)}$ ratio of 1:3, as visualised in the following reaction. For n=1, reaction (2) and (3) becomes identical.

$$3C_nH_{(2n+2)} + CO_2 + (3n-1)H_2O = (6n+2)H_2 + (3n+1)\ CO \quad (SN=2)$$

Kinetic and thermodynamic constraints

On the classic Ni-based reformer catalysts, CH_4 or CO can dissociate into carbon on the surface of the Ni crystals, leading to formation of soot or carbon fibres (whiskers), which will ultimately destroy the catalyst. In order to prevent this, steam is added to a suitably high steam/carbon (S/C) ratio. Alternatively, the carbon formation may be suppressed by sulphur passivated reforming (SPARG), or noble metal reforming. However, these reforming technologies have proven to be most suitable for production of CO and reducing gas, less so for methanol. Thus, the preferred solution for CO_2 reforming for methanol production is Ni-catalyst based reforming at a suitably high S/C ratio.

The carbon limit of equilibrated syngas is shown in Fig. 2. The S/C ratio is plotted along the upper left axis of the graph, CO_2/CH_4 is plotted along the lower left axis. The carbon limit is the S-shaped curve in the middle of the figure. To the right of the carbon limit there is no potential for carbon formation. To the left of the curve, carbon will be formed.

The arrow in the upper right part of the figure illustrates how addition of CO_2 increases the carbon potential because of the lower H/C atomic ratio of the feedstock.

The inerts concentration of the syngas is also very important for a methanol plant since the methanol synthesis occurs in a loop with a significant recycle. Therefore, any CH_4 that is not converted in the reforming section (CH_4 leak) will be accumulated in the synthesis loop by a factor up to 10, reducing the partial pressure of the active components.

The CH_4 leak through the reformer is controlled primarily by S/C ratio and reformer outlet temperature as illustrated in Fig. 3. In order to keep an inert concentration in the synthesis loop below 25%, the syngas should typically contain less than 2.5% CH_4, corresponding to a S/C ratio of 2.5 and 920°C outlet the reformer.

First large scale industrial application

The following description refers to a one million t/a methanol plant in Iran. The plant is located by the Persian Gulf in a

CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

petrochemical complex at Bandar Imam. At this site excess CO_2 is available from the ammonia plant and an ethylene cracker.

Given the availability of CO_2 and the rich composition of the natural gas for the Iranian plant, the CO_2/hydrocarbon ratio was fixed at about 0.26, resulting in a syngas stoichiometric number of about 2.09.

The Iranian methanol plant features a natural gas desulphurisation section (CoMo based hydrogenation and ZnO based sulphur removal) followed by a pre-reformer and the tubular reformer. The methanol synthesis takes place in boiling water reactors, and the product is purified in a three column distillation section.

This process layout (Fig. 4) results in a very energy efficient plant with an energy consumption of only 6.95 Gcal/t methanol (7.05 Gcal/t including CO_2 compression), i.e. 5-10% lower than the energy consumption of a conventional plant.

The inclusion of a pre-reformer serves several purposes, the most important being that it helps reduce the size of the tubular reformer, since all energy added in connection with the pre-reformer is subtracted from the tubular reformer. In the Iranian plant, the reduction in the tubular reformer duty is about 13% corresponding to about 75 reformer tubes.

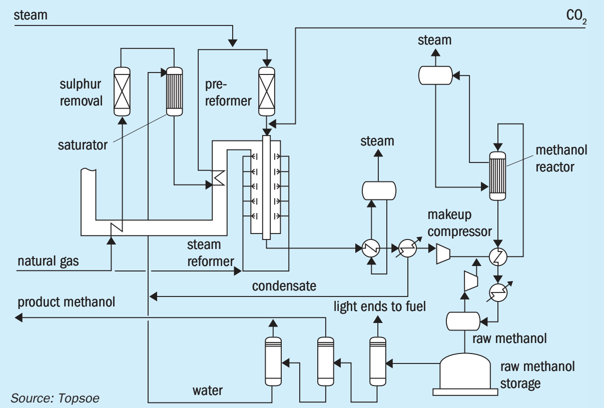
The imported CO_2 can be added to the methanol plant at various locations, typically either upstream of the reformer or at the suction point of the syngas compressor. From an overall mass balance point of view, the addition point makes no difference, but from the perspective of the plant subsections such as the tubular reformer or the synthesis loop, the difference is significant. For instance, the reaction rate in the methanol synthesis is highly dependent on the CO/CO_2 ratio of the syngas, and therefore the synthesis section benefits significantly when the CO_2 is added before the reformer, where most of it is shifted to CO. On the other hand, the addition point upstream of the reformer results in a higher reformer load.

In the Iranian plant, the CO_2 is added just after the pre-reformer.

CO_2 purification

CO_2 used for feedstock for a catalytic reaction must be free from potential catalyst poisons such as sulphur and halogens. If the CO_2 source is an NH_3 plant this does not pose a problem, but if the CO_2 originates from other sources, purification may be required.

Fig 4: **Process layout for a methanol plant with CO_2 reforming**



Source: Topsoe

Table 1: **Relative plant load by plant sub-section**

CO_2, flow	-10%	Design	+10%
Stoichiometric number	2.16	2.09	2.02
CO_2 compressor power	90	100	110
NG compressor power	102	100	98
Steam reformer duty	102	100	98
MUG compressor power	102	100	98
Recirculator power	87	100	116

Source: Topsoe

Removal of sulphur from CO_2 is difficult because a significant part of the sulphur may be present as COS. Both H_2S and COS may be removed on traditional ZnO adsorption mass, but unfortunately, the adsorption of COS requires much higher temperature than the adsorption of H_2S (~400°C vs ~200°C respectively). Preheating of the CO_2 stream to 400°C presents several logistic problems, and therefore other alternatives are sought.

Adding small amounts of water to the CO_2 stream will cause COS to hydrolyse to CO_2 and H_2S. However, water will also increase the sulphur slip from the ZnO adsorbent according to the reaction $ZnO + H_2S = ZnS + H_2O$. Consequently, this solution has certain limitations.

Mixing the CO_2 and the natural gas introduces another problem. The hydrogen recycle added to the natural gas in order to allow the hydrogenation to take place will also react with the CO_2 (the reverse shift reaction). The water formed by this reaction will cause increased sulphur slip.

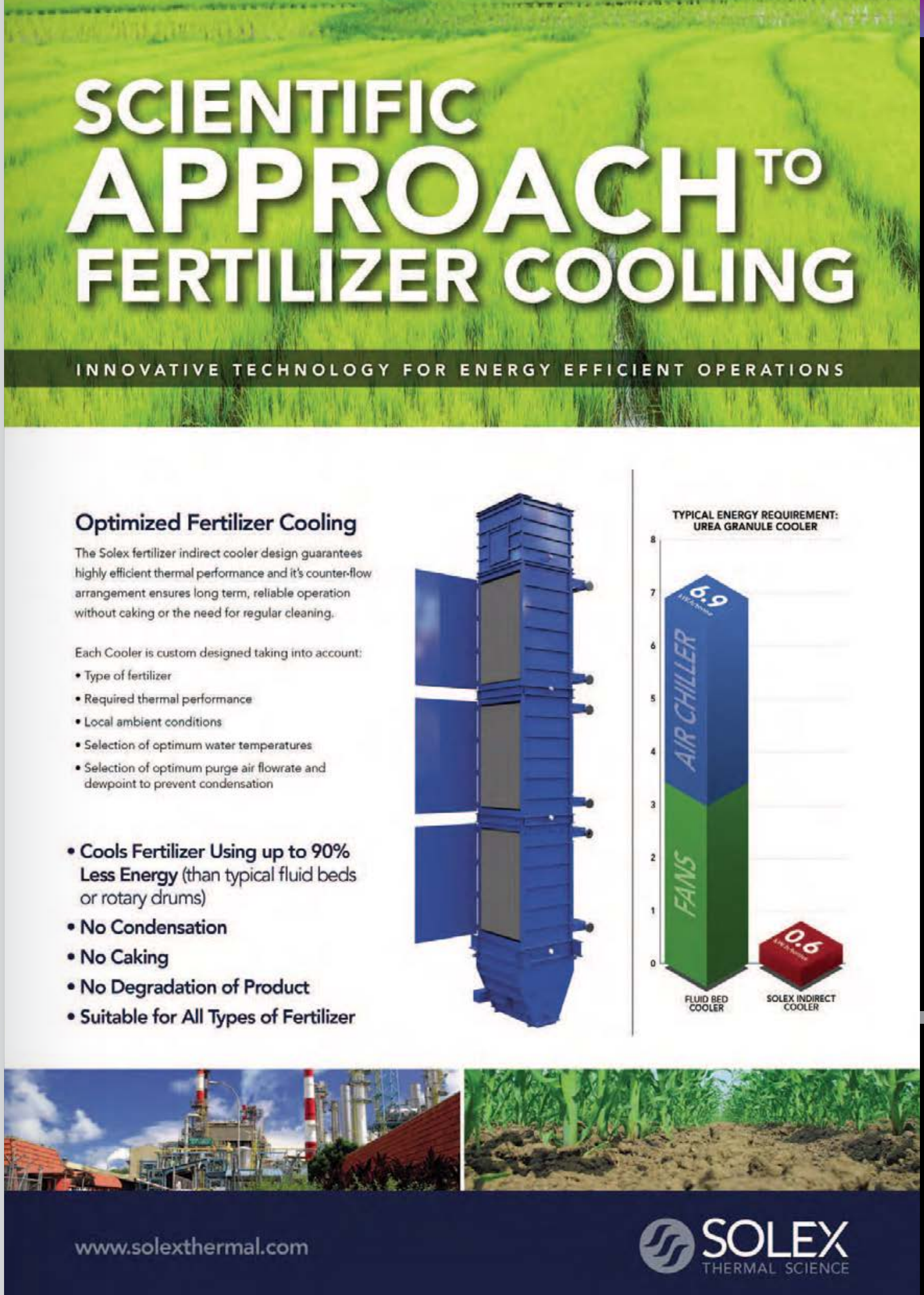
Finally, the CO_2 feed may be treated by a copper based adsorbent mass. Such adsorbent mass has already been applied industrially with success. While the copper based adsorbent is a bit more expensive than the ZnO adsorbent, it has the advantage that it is active at lower temperatures. So far it is considered the most suitable solution for dealing with sulphur in CO_2 feedstock.

CO_2 reforming to plant performance

Feedstock variations

When a plant has two different feedstocks, it is necessary to consider the effects, if the balance between the feedstocks changes. Obviously, the plant will have to be designed for a given feed balance, and deviations from this balance will lead to bottlenecks in different places of the plant. The distribution of bottlenecks is illustrated in Table 1.

The table shows how the requirements for the reforming section change by about



NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Table 2: **Typical key figures for a 1 million t/a methanol plant**

	Steam reforming	CO_2 reforming
Consumption figures:		
Energy, Gcal/t MeOH	7.4	7.05
Demin. water, m^3/t MeOH	0.8	0.4
Equipment and line size:		
CO_2 compressor, MW	-	3.7
Reformer size, no. of tubes	720	575
MeOH reactor volume, index	91	100
Dry syngas flow, Nm^3/h	385,000	325,000
Recirculation flow, Nm^3/h	1.2 million	1.2 million

Source: Topsoe

Table 3: **Typical distribution of energy consumption** (Gcal/t methanol)

Theoretical energy consumption	5.5
Irreversible heat loss in reforming section	0.2-0.3
Irreversible heat loss in synthesis section	0.3-0.4
Irreversible heat loss in distillation section	0.7-1.2
Irreversible compression loss in synthesis section	0.2
Net energy requirement	7.0-7.4

Source: Topsoe

2% when the available amount of CO_2 changes by 10%. The sensitivity of the recycle compression is due to the increasing difficulty to maintain the carbon efficiency of the synthesis loop as the SN approaches 2.

In principle, the bottlenecks have an impact on the production capacity when the feedstock balance changes, i.e. the maximum production will decline when the feedstock balance deviates to either side of the design point. In reality, it is possible to compensate for the worst bottlenecks to a certain extent. The Iranian plant, for instance, is designed with sufficient margins in the bottleneck areas to permit the full design capacity over the entire range from –10 to +10% CO_2. In case the import of CO_2 is completely terminated, the plant will still be able to produce about 2,500 t/d methanol on natural gas alone.

Comparison to conventional layout

The CO_2 addition results in a plant performance quite different from the performance of the conventional layout. The major differences are indicated in Table 2.

The lower energy consumption of CO_2 reforming is due to simple substitution of natural gas with CO_2, whereas the lower demineralised water consumption is due to water formed by the reverse shift reaction.

With respect to equipment and line size, it is well worth noticing that the reforming section is significantly smaller for the CO_2 reformer plant while the synthesis reactor is slightly larger. With about 60% of the plant investment in the reforming section and only 10-15% in the synthesis section, however, the overall effect is a substantial cost reduction.

CO_2 sequestration

The manufacture of methanol partly (or completely) from CO_2 has been discussed as a tool for CO_2 sequestration. It should be realised, however, that the potential for CO_2 sequestration might be seriously limited not only by mass balance limitations, but also by the energy requirement of the manufacturing process.

In a typical methanol plant, a large amount of energy is consumed in the reformer, but the latent heat of the resulting flue gas is recovered to a very large degree. In contrast, most of the energy used in the compression and in the distillation is irreversibly lost.

A typical breakdown of energy consumption is shown in Table 3. The reason for the large range on heat loss in the distillation is that this section often is used as a heat sink for the process, reflecting the efficiency of the reformer section. This table gives a good impression of the CO_2 sequestration obtainable under various circumstances.

If natural gas is the only source of energy for the plant, the CO_2 emission is given by the amount of natural gas required to generate a heating value of 7.0 Gcal/t methanol. Comparing with the typical energy consumption of 7.4 Gcal/t and the theoretical energy consumption of 5.5 Gcal/t, the overall CO_2 emission can thus be reduced by 20-25%.

It is important to realise, however, that even though a methanol plant imports CO_2, this CO_2 is not permanently sequestrated. The CO_2 addition changes the quantity and composition of the purge gas from the methanol synthesis loop, so that the fuel gas (and consequently also the flue gas) for the reformer becomes more carbon rich. As an example, the 825 t/d of CO_2 imported for the Iranian methanol plant is matched by an increase in flue gas CO_2 content of about 450 t/d, and therefore the net CO_2 sequestration will be only about 375 t/d or about 0.12 ton CO_2/t methanol.

Johnson Matthey's LCM process

The performance of a large methanol plant using oxygen-based autothermal reforming can be substantially improved by coupling the ATR with a gas heated reformer (GHR). The fundamental heat-recycle feature of Johnson Matthey's GHR technology brings wide-spread efficiency and environmental benefits to methanol production with respect to big reductions in gaseous and liquid effluents compared to alternative production routes.

For methanol production operating at a steam ratio of 2.0 the GHR provides an efficiency benefit of at least 5%, CO_2 emission reductions of up to 40% and a reduced capital cost.

Efficiency

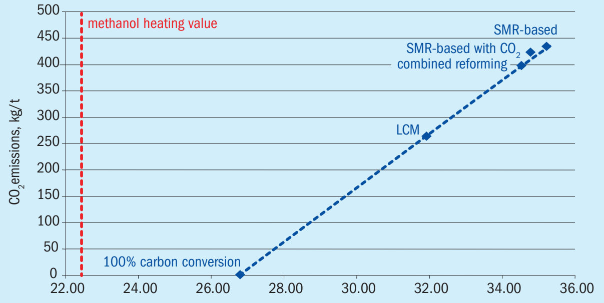
The Leading Concept Methanol process (LCM) is naturally a high efficiency process due to the effective recycle of high-grade heat in the GHR. In order to compare different processes, full plant heat, mass and power balances have been carried out for three different process configurations. All simulations are based on the same natural gas feedstock and the same atmospheric conditions, with all balances being closed out so that the plants are self-sufficient in power. The three processes considered are: an SMR-based process such as Johnson Matthey's LPM process; a combined reforming process, i.e., one using a conventional SMR plus an oxygen-blown ATR; and LCM. Because CO_2 addition is an important option for SMR-based plants, this case has also been included.

Table 4: **Efficiency and utilities comparison between processes in a hot climate at end of catalyst life using a light NG with 5% CO_2 content**

	SMR-based	SMR with stoichiometric CO_2 addition	Combined reforming	LCM
Efficiency (GJ/t HHV)	35+	34	33+	32
CO_2 emissions (kg/t)	433	353	325	263
Water make-up (kg/t)	625	400	100	75
Net Power (MWhr/t)	0	0	0	0

Source: Johnson Matthey

Fig 5: **CO_2 emissions as a function of efficiency**



Source: Johnson Matthey

Table 4 shows the indicative efficiency and other important utilities consumption figures per tonne of methanol.

CO_2 emissions

Fig. 5 shows the impact that improved efficiency has on the amount of CO_2 sent to the atmosphere. The relative reduction in CO_2 emissions is a multiple of the relative improvement in efficiency of the LCM process. This can easily be explained by calculating the efficiency of a plant that converted all the carbon in the natural gas into methanol. For the gas composition considered, the efficiency (HHV basis) would be 26.82 GJ/t for complete carbon conversion. This point can be plotted alongside the efficiencies and CO_2 emissions from Table 4.

This clearly illustrates the rapid fall in emissions as the efficiency moves towards the 100% carbon conversion figure. The figure shows another interesting fact, and one that is often misunderstood. In the case of SMR-based with CO_2 addition, the quantity of CO_2 used was 360 kg/t of finished product. It is often assumed that this would represent a 360 kg/t reduction in CO_2 emissions, but clearly, this is not the case, the reduction only being around 100 kg/t. The reason for this is that while the CO_2 added to the feed may all be converted into methanol, it consumes the excess hydrogen that would otherwise be in the purge from the loop that would be burned as fuel. The loss of hydrogen as a fuel has to be replaced by natural gas that generates the extra CO_2 in the flue gas. So adding CO_2 to the feed does not generate a 1 for 1 reduction in emissions, but still leads to a significant reduction.

Fluor's cost effective CO_2 capture

Fluor's Econamine FG Plus^{SM} (EFG+) technology is a proven, cost-effective process for the removal of CO_2 from low pressure gases containing oxygen, such as an SMR flue gas. In the following case study, Fluor's Econamine FG Plus^{SM} technology is used for recovering sufficient carbon dioxide from the SMR flue gas in a natural gas based 1,200 t/d methanol plant to expand the plant capacity by approximately 20%.

Implementation strategy

Fig. 6 shows a simplified block flow diagram of the natural gas-based methanol plant (base case = SMR with no CO_2 addition. The recovered carbon dioxide can be returned to the process in different ways. It can be injected either into the feed to the steam reformer (option 1), or directly into the make-up gas to the methanol plant prior to compression (option 2), or some combination of the two. In any case, sufficient carbon dioxide needs to be returned to the process such that the stoichiometric number (SN) of the make-up gas is 2.05.

Adding the CO_2 into the steam reformer feed gas results in a higher ratio of CO to CO_2 in the make-up gas, which leads to less water in the crude methanol stream. However, because the CO_2 is sent through the steam reformer, the increased reformer throughput increases the reformer heat duty. For an economical revamp or in cases where the original plant has sufficient margin, lowering the steam to carbon ratio could be considered to maintain the original reformer heat duty.

Option 2, in which CO_2 is directly injected into the make-up gas to the methanol plant, has minimal impact on the steam reformer heat load and the process steam demand for a given methanol production as compared to option 1. However, the implementation of option 2 results in higher water content in the crude methanol product and this might adversely impact the methanol distillation system.

After careful consideration of the plant design and hydraulics, option 1 was selected for this study.

Impact on the SMR flue gas composition

The injection of CO_2 into the methanol plant as per options 1 or 2 will affect the steam reformer flue gas composition. Hence, the flue gas composition needs to be recalculated before it can be used as the basis for the design of the Econamine FG Plus^{SM} plant.

Methanol plant simulations were developed to determine the effects of adding the recovered carbon dioxide and hydrogen back to the process. From these calculations, it can be seen that when the SN of the make-up gas is corrected, the methanol loop becomes more efficient, resulting in the following effects:

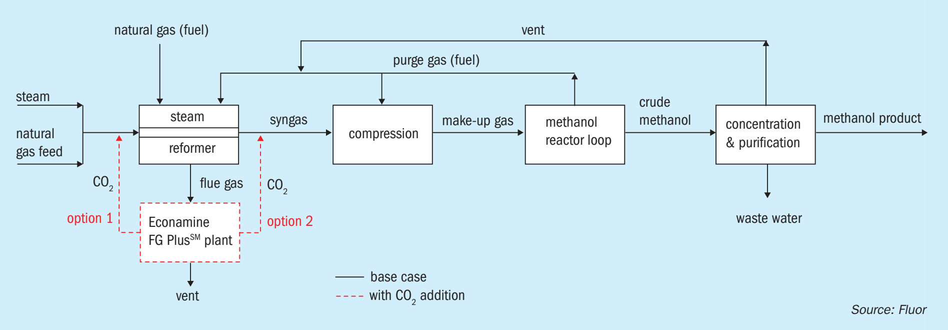
CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Fig 6: **Methanol plant block flow diagram showing options for CO_2 addition**



Source: Fluor

- the hydrogen consumption efficiency increases
- the purge gas rate decreases
- the hydrogen concentration of the purge gas decreases (and the CO_2 concentration increases).

The changes to the purge gas rate and composition results in an increase in the rate of natural gas firing (as fuel) in the SMR. The net result is an increase in the CO_2 concentration of the flue gas. The calculated change in flue gas from the base case is shown in Table 5. (Note that the compositions shown in this table assume that the reformer convective section is air tight, i.e. there is no air infiltration into the convective section.)

The flue gas composition listed in Table 5 for option 1 (or alternatively option 2) can be used for the basis of the Econamine FG Plus℠ plant.

In addition to an increase in CO_2 concentration, the quantity of CO_2 available for recovery also increases for Option 1 and 2 over the base case. This is important, since the amount of CO_2 recovery required to achieve a stoichiometric ratio of 2.05 was greater than the amount of CO_2 available in the base case flue gas. At the modified flue gas composition and flow rate for option 1, approximately 59% of the carbon dioxide from the flue gas would have to be recovered for injection to the process.

Because of the change in carbon dioxide concentration and flow rate in the reformer flue gas that accompanies CO_2 injection into the methanol plant, the base case flue gas should not be considered for CO_2 recovery.

If the same radiant heat duty were used for option 1 configuration as that required for the base case, the syngas production would be sufficient for an approximate 22.5% increase in the nominal methanol production rate from 1,200 t/d to almost 1,500 t/d.

Table 5: **Flue gas compositions for three cases**

Composition (mol-%)	Base case	Option 1	Option 2
CO_2	4.2	8.7	8.6
N_2	67.8	70.7	70.1
O_2	1.0	1.0	1.0
H_2O	27.0	19.6	20.3

Source: Fluor

When considering CO_2 injection for adjustment of the stoichiometric ratio, consideration must also be given to the operating and expansion limits of the methanol plant. Specific items to consider include:

- operating/expansion limits of the SMR, including the convective section
- operating/expansion limits of the syngas compressor
- operating/expansion limits of the methanol reactor loop
- best location(s) for adding CO_2 to the process to improve the make-up gas stoichiometry.

Carbon capture unit (Econamine FG Plus℠)

Calculations indicate that if the same SMR radiant heat duty were used for the option 1 configuration as that required for the base case, the syngas production would be sufficient for an approximate 20% methanol production rate increase.

Performance of carbon dioxide recovery unit with 500 t/d nominal capacity is predicted.

Fluor can offer its proprietary Econamine FG Plus℠ (EFG+) technology for the carbon dioxide recovery unit.

Fluor has built or licensed 28 amine plants worldwide based on its EFG+ technology The EFG+ technology utilises a solvent formulation that is specially designed to recover carbon dioxide from low pressure, oxygen-containing streams, such as a boiler and reformer stack gas and gas turbine flue gas streams.

One of the challenges to installing a carbon dioxide recovery unit on any of these types of gas streams is the pressure sensitivity of the upstream unit. Fluor has successfully installed EFG+ units on the exhaust duct of a gas turbine in a power plant, where neither backpressure nor pressure fluctuations can be tolerated. The technology is also located on steam-methane reformer flue gas lines in Brazil and Singapore.

These plants have consistently removed the carbon dioxide from the flue gas without disturbing the upstream pressure.

The two EFG+ plants that were installed on steam-methane reformers in Brazil were each designed with a capacity of 90 t/d CO_2 with the first one being commissioned in 1997.

The CO_2 recovered was used both for the food industry and to increase methanol production.

The EFG+ plant installed in Singapore was commissioned in 2002. This plant was designed to recover 36 t/d of CO_2 from a steam reformer flue gas with the recovered CO_2 being used in the food industry.

The CO_2 produced from the EFG+ process is of high purity (>99.9% dry basis). Fluor continually focuses on improving the EFG+ process configuration to lower the energy consumption by developing solvent and flowsheet enhancements. Some of the improvements realised in the last seven years include:

- improved solvent formulation
- absorber intercooling
- low pressure drop packing in the DCC and absorber columns
- lean solvent flash configuration
- large column design.

Many patents have been issued and more are pending on various other design aspects to improve performance and remain a world leader in the industry of carbon capture.

The above list serves as a menu of options from which a customised plant design can be developed.

Each CO_2 removal application has unique site requirements, flue gas conditions and operating parameters. Based on the given CO_2 removal application, it may be beneficial to implement only some of the enhancement features listed above. In this way, every plant will be optimised for its specific CO_2 removal application.

The overall energy demand associated with a customised EFG+ plant can be up to 25% lower compared to that of a non-customised plant.

Improved solvent formulation

The improved solvent formulation results in increased reaction rates, which decreases the required packing volume in the absorber, thereby lowering capital cost. Utilising both the low pressure drop structured packing along with the improved solvent formulation, the packing volume required for CO_2 absorption is reduced by up to 40%. Furthermore, the improved solvent also has higher solvent carrying capacity for carbon dioxide, thus decreasing the solvent circulation rate; this reduces the plant steam requirement by up to 10% along with lowering the capital cost for solvent circulation equipment.

Absorber intercooling

As the EFG+ solvent absorbs CO_2, heat is released and the solvent warms. The warming has two effects:

- the reaction kinetics between the CO_2 and the solvent leading to improved absorption
- decreased CO_2 carrying capacity of the solvent leading to decreased absorption.

Fluor has developed absorber intercooling to optimise the absorption temperature profile by removing excess reaction heat from the column, thereby improving absorption while also increasing the solvent's CO_2 carrying capacity.

With intercooling, less solvent needs to be circulated for every ton of CO_2 that is absorbed.

Solvent regeneration energy is also reduced since a smaller quantity of solvent needs to be regenerated. When applied, absorber intercooling reduces the EFG+ plant energy consumption by 5-10%.

CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Low ΔP packing in the DCC and absorber columns

Fluor employs structured packing in the direct contact cooler (DCC) and absorber columns specifically designed to provide a large area for mass transfer while maintaining very low pressure drops throughout the flue gas path. Low pressure drop through the flue gas path is imperative in order to minimise the blower electrical power that is necessary to push the flue gas through the EFG+ plant. The low pressure drop packing in the DCC and absorber columns reduce the pressure rise across the blower by 40-50%. This smaller pressure rise in the blower directly leads to reduced electrical power consumption resulting in a lower annual operating cost.

Lean solvent flash configuration

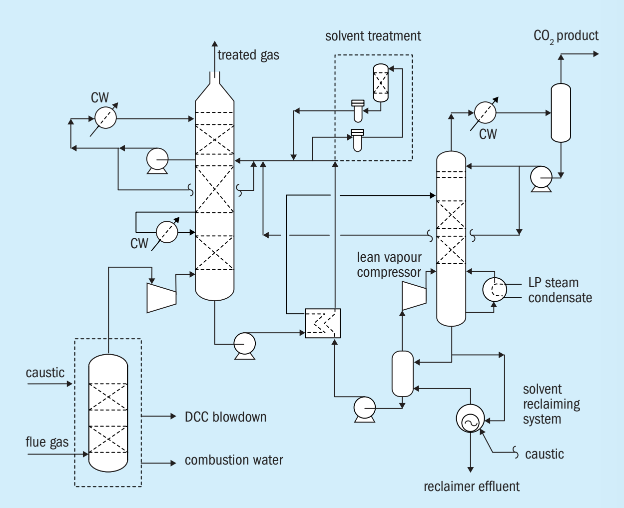
In a standard EFG plant, the lean solvent from the stripper, containing a low loading of carbon dioxide, is cooled and routed to the absorber.

Fluor now offers a lean vapour flash configuration (patent pending) in which the hot lean solvent from the stripper is flashed at low-pressure in a flash drum. The resulting flashed vapour consists mostly of steam with small amounts of carbon dioxide and solvent. The flashed vapour is compressed in a thermo-compressor and returned to the bottom of the stripper where it flows upward through the column while stripping CO_2 from the rich solvent.

With a portion of the stripping steam requirement being supplied by the flashed vapour, the reboiler steam requirement is reduced. Since the temperature of the lean solvent is reduced in the flash drum, the temperature of the rich solvent leaving the cross exchanger is also reduced, thereby lowering the temperature at the top of the stripper. This results in a lower cooling load in the condenser and therefore, a lower overall plant cooling water requirement.

Both the capital cost and power requirements of the plant increase with the lean vapour compression configuration. However, the steam savings in the reboiler very often pay for the increased costs elsewhere. Ultimately, the benefits of this configuration are dependent on the relative costs of steam and power, but Fluor has encountered several cases for large-scale plants where this configuration pays out in a relatively short period of time due to an overall energy demand reduction of 5-15%.

Fig 7: **Econamine FG Plus^{SM} for CO_2 recovery of 500 t/d**



Source: Fluor

Utilities and chemicals

As indicated by Fig. 7, an EFG+ plant requires the following utilities and chemicals:

- low-pressure steam for solvent regeneration and reclaiming
- electrical power
- cooling water (air cooling can also be implemented)
- demineralised water
- make-up solvent
- soda ash or sodium hydroxide for solvent reclaiming.

Other utilities also required that are not indicated by Fig. 7 include nitrogen for blanketing, instrument air and plant air.

Solvent reclaiming and waste generation

Solvent reclaiming is required to remove contaminants from the circulating solvent loop that cannot be removed by the in-line cartridge filters or activated carbon filtration bed. These contaminants include heat stable salts and non volatile degradation products. The solvent reclaimer concentrates and removes these contaminants as a waste that must be periodically hauled off-site for disposal. Without solvent reclaiming, these contaminants would build-up in the circulating solvent loop and continually degrade the plant performance until the entire solvent inventory would periodically need to be drained, disposed of, and replaced. Therefore, the reclaimer system serves to minimise the overall plant waste generation.

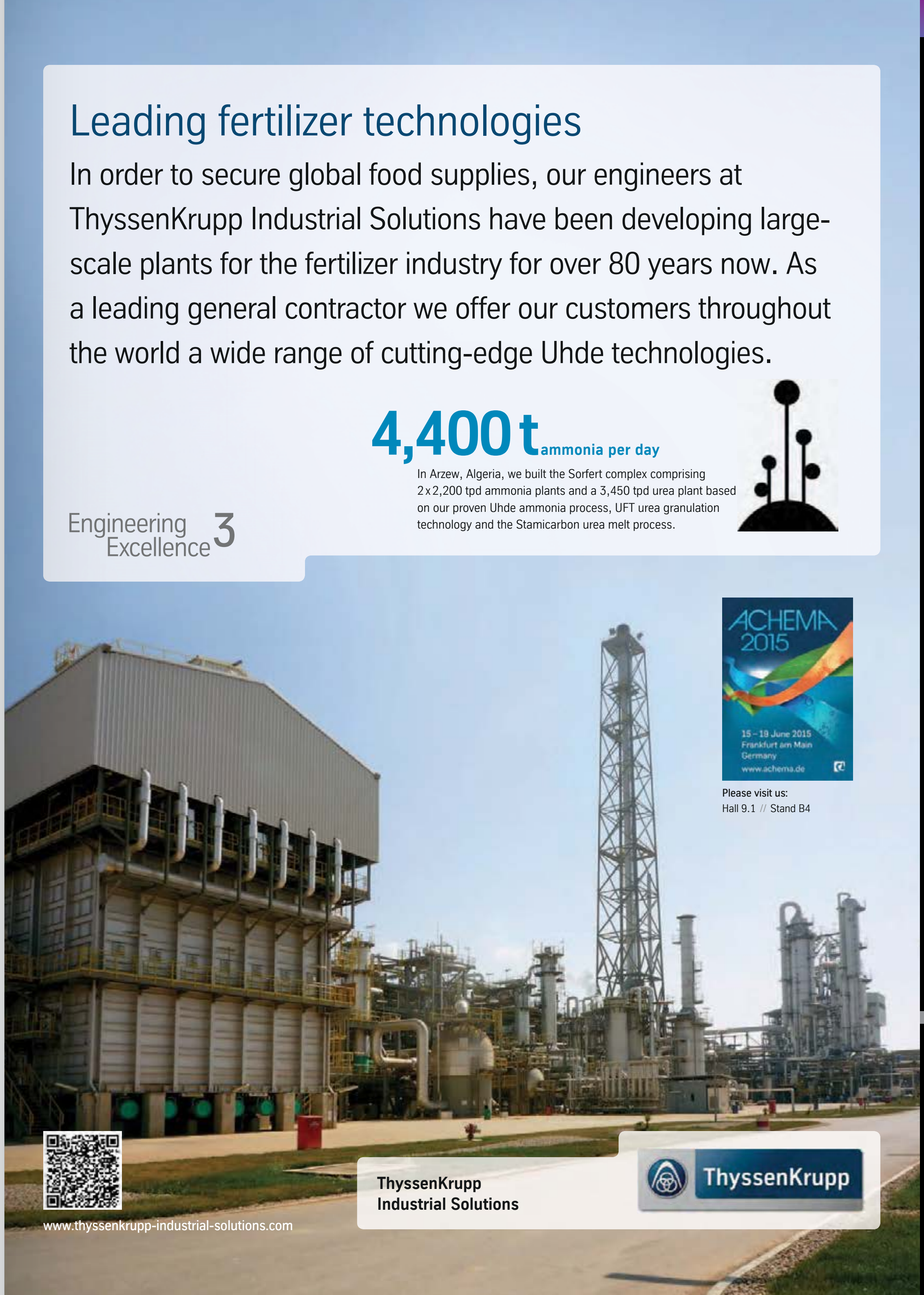
In addition to non-regenerated heat stable salts and non-volatile degradation products, the reclaimer waste consists of unrecovered solvent, water and soda ash or caustic solution. The quantity of reclaimer waste generated is highly dependent on flue gas characteristics including, but not limited to:

- SOx and NOx concentrations
- oxygen partial pressure.

For SMR-based flue gases, which typically have very low SOx, NOx and O_2, the reclaimer waste generation is on the order of 0.1-0.2 kg/t of CO_2 recovered. ■

References

1. Holm-Larsen H. (Haldor Topsoe): “CO_2 reforming for large scale methanol plants – an actual case” (2001).
2. Farnell P.W. (Johnson Matthey): “Johnson Matthey’s advanced synthesis gas generation technology portfolio: An opportunity to improve the environment”.
3. Reddy S, Bhakta M., Gilmartin J. and Yonkoski J. (Fluor Enterprises): “Cost effective CO_2 capture from flue gas for increasing methanol production”, Ammonia Safety Symposium (2014).



CONTENTS
What's in issue 335

COVER FEATURE 1
Urea markets

COVER FEATURE 2
India's subsidy policy

COVER FEATURE 3
CO_2 in methanol production

COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Fertilizers of superior uniformity

Mark Brouwer of UreaKnowhow.com reports on how Sandvik's Rotoform system can be used to deliver fertilizer-quality urea and blended products in a form that offers advantages to both producers and end users.

For a fertilizer to be effective, two fundamental requirements must be satisfied. Firstly, it must contain the nutrients necessary to promote the healthy growth of the particular crop(s) for which it is designed. Secondly, it must be produced in a form that enables even and consistent delivery to the soil. Both of these require a high degree of product uniformity.

In today's market, professionals like turf grass managers, golf course superintendents and landscape managers will generally choose from three types of dry fertilizer:

- granular bulk blend fertilizers
- homogeneous Rotoform product fertilizers
- homogeneous product fertilizers containing blends of two or three different nutrients.

To consider granular blends first, achieving uniform distribution can be a major challenge. Why? Well, there are three forces working against uniform distribution:

- coning segregation
- sifting segregation
- ballistic segregation.

Actual field measurements have shown variations of anything from 50% to 225% in the recommended amount of dry granular blend fertilizer as a result of the forces of segregation.

The unsightly results of such non-uniform application will be apparent very quickly, and this can be devastating on the intensely managed turf grass of golf course greens and fairways.

To achieve uniform distribution, the fertilizer shape and size also need to be uniform. One measure for the uniformity is the Uniformity Index (UI).

The UI of a product is typically defined as D5/D90*100%. Prill and granulation technologies will normally achieve a UI of between 50 and 70%, but Sandvik's Rotoform process can offer a UI of at least 75-80%. The advantage of this is clear: fertilizers with a high UI show significant benefits in bulk blending applications as less segregation and uneven application will occur.

Major benefits of nutrient interaction

Research has shown that the maximum influence of nitrogen occurs when the nitrogen and phosphate work together. This kind of chemical combination is found only in homogeneous pellets or high quality pellet blends. If the nitrogen is separated from the phosphorus by as much as 50 mm, there can be as much as a 50% reduction in phosphorus uptake by the plant. The agronomic advantage is called nutrient interaction.

Likewise, there is a similarly positive interaction between nitrogen, phosphorus and sulphur in terms of increasing the availability and efficiency of each of these important turf grass nutrients.

In summary, granular dry blend fertilizers are mixtures of particles of different sizes, shapes and weights. The forces of segregation add to the non-uniformity of blends of this type and uniform application becomes extremely difficult. Uneven distribution of nutrients even within the same spreader swath or band can result in uneven growth, lack of uniform colour, and increased management problems.

In order to provide a solution, it's important to understand why granular dry blend fertilizers are made up of particles of such widely differing size and weight.

Fig 1: **Casale Vortex® granulator**

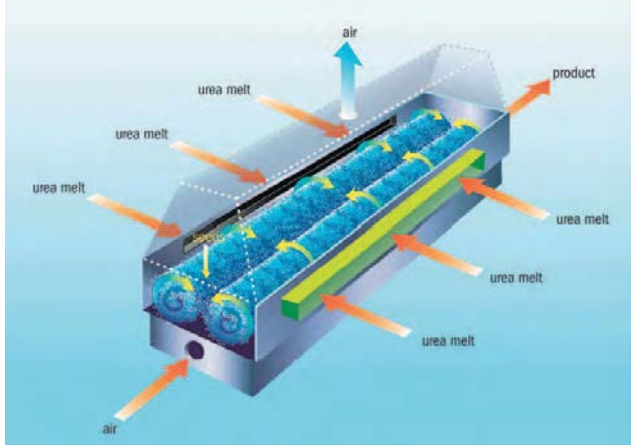
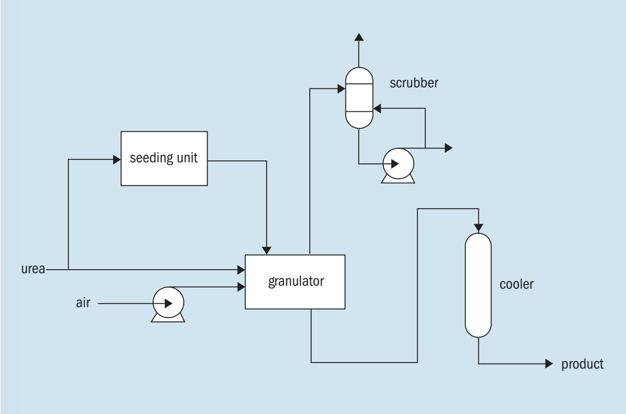


Fig 2: **Casale Vortex® granulation process**



Granulation process

The urea granulation process is based on the crystallisation of urea melt on seeds, resulting in a slow growth until the desired size is achieved.

A typical fluid bed granulation system will start with seeds of between 1 mm and 2.2 mm, and granules of between 1 mm and 6 mm will be delivered at the outlet end. These products will then be screened.

Products that are too small (e.g. < 2mm) will be recycled as seeds; correctly sized products (e.g. 2-4 mm) will be cooled and sent to storage; and oversize products (e.g. > 4 mm) will be broken up in a rolling crusher then also be recycled as seeds.

Crushing is an inefficient process both in terms of the wide range of particles produced and also in the costs associated with managing the large amount of dust (crushing is the second largest source of dust formation in a fluid bed granulation process). Dust recovery alone requires a significant amount of energy, and additional investment is needed for the dust scrubber and further recovery equipment.

Improving product quality

The ability to control the flow and residence time of the seeds in the granulator can overcome this inefficiency, reducing the range in sizes of the outlet product, and recent developments in fluid bed granulation (e.g. the bed designs of Casale and Green Granulation Technology) are focused on achieving precisely this.

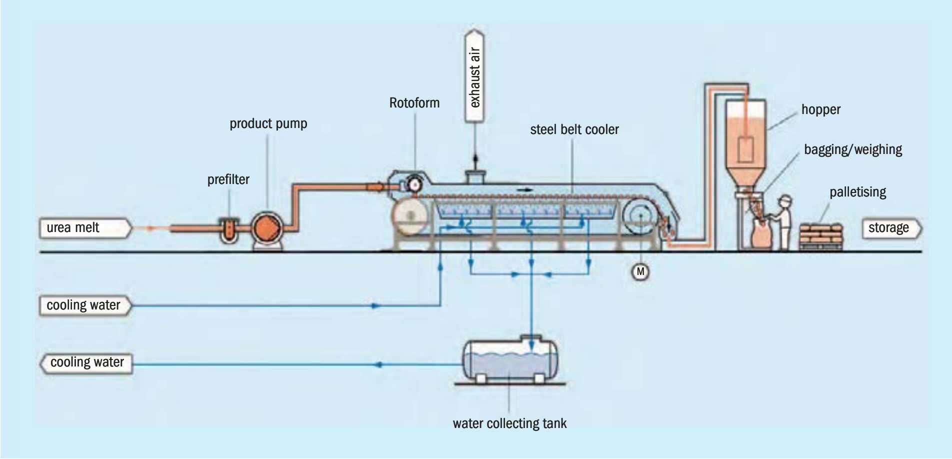
The Casale Vortex granulation process (Figs 1 and 2) is a 'once through' system requiring no screening, crushing, additional bucket elevator or other related recycling equipment. It also produces less dust and therefore requires significantly less dust recovery equipment.

For this system to deliver maximum efficiency however, it's essential that the seeds are as uniform in size as possible. And in order to achieve this, Casale has worked closely with granulation system manufacturer Sandvik Process Systems, using its Rotoform system (Fig. 3) to produce micropastilles of urea with high crushing strength and a diameter of just 1.3 mm.

Trials on the 1.3 mm seed pastille in the vortex granulation process have proven highly successful, delivering a 3 mm urea granulated product with excellent size distribution.

While Rotoform pastilles are actually hemispherical, at this small size the difference in performance between this form and a completely spherical seed product is negligible. Furthermore, the significant

Fig 3: **Sandvik Rotoform process for urea**



CONTENTS
What's in issue 335

COVER FEATURE 1
Urea markets

COVER FEATURE 2
India's subsidy policy

COVER FEATURE 3
CO$_2$ in methanol production

COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Fig 4: **Urea granule**

Fig 5: **Rotoform belt with urea pastilles**

growth factor, from 1.3 mm to 3 mm, results in a final product that is virtually spherical anyway. Fig. 4 shows a urea granule produced from Rotoform seed pastille and a Vortex granulator.

Production of seed pastilles

The urea melt is delivered to the Rotoform under pressure (2-3 barg) at a concentration of 99.6 wt-%. In existing urea plants this could be branched off from the urea evaporation section downstream of the urea melt pumps.

The patented Rotoform drop former consists of a heated stator and a perforated rotating shell that turns concentrically around the stator to deposit drops of urea across the full width of a continuously operating stainless steel belt (Fig. 5). The circumferential speed of the Rotoform is synchronised with the speed of the steel belt cooler ensuring that the drops are deposited on the belt without deformation.

The rotating shell contains rows of small holes, which are sized to deliver the required product size, in this case 1.3-1.5 mm. The heat released during crystallisation and cooling is transferred to cooling water sprayed against the underside of the steel belt, resulting in controlled solidification and consistently shaped urea pastilles. The cooling water is collected in pans, cooled in a cooling system (cooling tower) and returned to the Rotoform units.

Under no circumstances can the cooling water come into contact with the urea product. The use of formaldehyde is not necessary in this technology to realise pastilles with a high crushing strength. The pastilles are very uniform and additional screening is not needed. After solidification the pastilles are smoothly released from the steel belt and then fed directly onto the fluid bed granulator.

The section above the moving steel belt is enclosed with a hood and vented to an existing vent system (Fig. 6). There are no large air flows involved in this technology and there is no visible urea dust emission. What ammonia vapours are produced can easily be captured in a simple atmospheric absorber; this results in negligible emissions of ammonia and urea, a unique feature of this technology.

The result is a highly efficient solution for fluid bed granulation system. Uniform seeds give more uniform granules and eliminate the need for an additional conveyor for the seeds and recycling of off-spec granules.

High quality fertilizer blends

As well as being used to produce the starting seeds required in granulation, the Rotoform process can also be used to produce high quality, uniform pastilles in its own right, both fertilizer grade urea and specialty blended urea products.

Blends can deliver increased nutrient efficiency through positive nutrient interaction, and the consistent size and shape of Rotoform pastilles means blends manufactured this way deliver the key benefit of even application.

The following products have all been produced on the Sandvik Rotoform process:

- fertilizer grade urea
- technical urea for urea-formaldehyde, melamine, ad blue production
- urea blended with micronutrients
- urea with ammonium sulphate
- urea with elemental sulphur
- ammonium nitrate
- calcium nitrate
- magnesium nitrate
- sulphur bentonite

The production process of these specialty urea products is fairly simple and straightforward. A blending unit is applied to grind and mix the solid additives in the urea melt. For example, for urea plus ammonium sulphate (AS), urea melt and solid AS are mixed and grinded in two steps in a blending unit, which is a standard packaged unit. Up to 50 wt-% AS has been mixed with urea with excellent results. ■

Fig 6: **Rotoform skid-mounted equipment showing hood**

Cold recycle fluid bed granulation

K. Monstrey of Green Granulation Technology introduces a novel urea granulation technology where energy saving, low investment costs and high product quality are combined in a new layout and optimised production process.

Fig 1: **Building height**

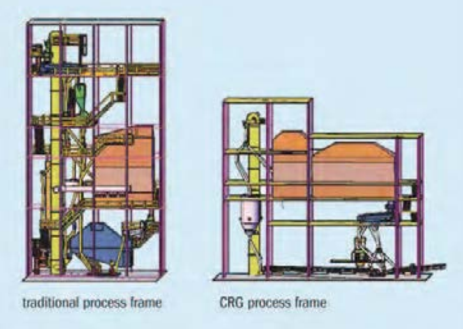
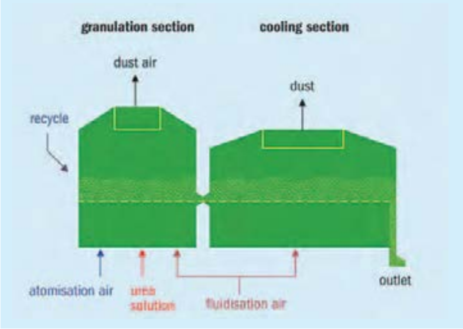


Fig 2: **Granulator and cooler in-line**



Green Granulation Technology (GGT), a leading provider of fertilizer related process technologies in China, has developed a new urea granulation process that has been named cold recycle granulation or the CRG process. The essence of the process lies in handling cooling in a single step so that screening, crushing and recycling takes place with cold product. In this way, screens and crushers can be kept clean for longer and less dust is produced during processing. The CRG process has reduced the investment and operational costs of urea granulation, while optimising product quality and reducing dust emissions.

The first cold recycle fluid-bed urea granulation technology process was successfully applied in one of GGT's projects in China in 2013 (3,000 t/d). Since then, over 11,000 t of daily capacity are under construction or being commissioned.

The CRG process combines energy savings, low investment costs and high product quality in a new layout and an innovative production process.

Building height

GGT has completely reworked the traditional idea of the layout of a urea granulation unit, resulting in a much lower building that offers convenient access to operators (Fig. 1). Not only does it make construction much cheaper, it also allows operators to move more quickly and efficiently throughout the plant.

The most drastic saving in height comes from the use of a single cooler that is in line with the granulator (Fig. 2). The cooler automatically operates at the same bed-level as the granulator. The granulator has no cooling compartments, only injection compartments. As a result, the product entering the cooler is at a temperature above 100°C. The cooler outlet temperature is set according to the client's requirements. Since the cooler is operating at a relatively high bed level, the CRG process achieves the maximum polishing effect in the cooler.

A single cooler handles all cooling, down to product end-temperature, so screening of the product and crushing of the oversize granules takes place with cold product.

GGT has combined the screen feeder and safety screen into one single apparatus, resulting in a considerable saving in height. This is only possible due to the site layout in which the vibrating screens and crusher(s) are located below the granulator/cooler instead of the more conventional arrangement where the safety screen is located upstream of the bucket elevator.

Diverters traditionally require a lot of height, especially the additional diverters for forestry size. GGT is able to control the granulator seeding for big size, eliminating the need for this diverter. During design, GGT has spent a lot of time and effort in minimising the required height for the diverters, without compromising on the free flow through the device.

Building strength

Screens with horizontal gyratory screening movement, as well as other types of vibrating screens, are very demanding when it comes to the required strength of the building. A building has to be designed

■ CONTENTS
What's in issue 335

■ COVER FEATURE 1
Urea markets

■ COVER FEATURE 2
India's subsidy policy

■ COVER FEATURE 3
CO_2 in methanol production

■ COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Table 1: **Removal of crystallisation heat by water evaporation**

Water content in the urea feed solution	Heat removed by evaporation
0% (100% urea solution)	0%
1.5% (98.5% urea solution)	10%
3% (97% urea solution)	22%
4% (96% urea solution)	35%
5% (95% urea solution)	40%

and constructed is such a way that it can not only withstand the weight of the different components, but also the rotating vibrations that some of the equipment produces. This implies that, for a urea granulation building, one should take into account the harmonic vibration of all (2, 4 or even 6) vibrating screens, when calculating the strength of the building. The laws of physics prescribe that a tall building with a strong source of vibrations in the top must be much stronger than a low building with the source of vibrations located in the lower part. By locating the vibrating screens directly below the granulator/cooler, GGT is reducing the need for a building that is extremely strong up to the top.

In addition, GGT has opted to locate the scrubbers on the ground using an integrated scrubber circulation tank so there is no need for an underground tank.

Upstream related investments

The CRG process is able to use a urea melt feed of 95-96% (at the sprayers). Therefore, there is no need for a second evaporation section in the urea synthesis plant, construction costs are reduced and power consumption is lower due to the high water content of the melt. Table 1 shows the effect of water content in the urea melt feed on the heat balance of a urea granulation. This makes the CRG process very flexible. It can be linked to whatever existing urea synthesis technology is currently marketed.

Power consumption

Optimised internal dynamics in the fluid bed

For fluid bed granulators it is vital to ensure proper flow of particles towards the sprayers. One solution is to use a thick bed layer (starting from 600 mm WC pressure drop over the bed and perforated plate). Such a thick fluid bed becomes a "bubbling bed". This means that small air bubbles are formed at the perforated plate and, while rising, these bubbles grow in size until they explode when reaching the surface of the bed. It is this bubbling phenomenon that ensures a wild and uncontrolled movement in the bed and the product transport to the sprayers. This solution comes at a price, namely high fluidisation air pressure, since it only becomes effective from at least 600 mm WC pressure drop. If no other aid for circulation inside the bed is provided, this movement by bubbling is absolutely vital for a thick layer fluid bed. If no bubbling is obtained because of lack of air or bed thickness, the moisture of the end-product will automatically be high.

GGT has developed and patented technology which implies a fluid bed granulator in which the sprayer arrangement involves spraying zones and drying zones. Seed material is sucked towards the spray zone by the combined upwards action of atomisation and fluidisation air. During the pass through the spray area they grow by the sprayed-on urea melt. Once passed through the spray zone, the granule/seed will automatically flow into the still zone where the sprayed-on solution is given time to further evaporate while the granule/seed is sinking down for another pass through a spray zone. By optimising the movement in the bed in this way, the different spray zones are able to handle much more product, without overloading the spray zone which would lead to higher moisture. The principal of optimised movement in the bed has allowed GGT to lower the bed level of the fluidised layer down to 450 mm WC instead of the earlier mentioned +600 mm WC. This optimisation in combination with good spraying conditions has greatly reduced the need for residence time in the granulator.

Deep vacuum in the granulator

The lowered bed in combination with the low pressure drop scrubbers has made it possible for GGT to design a urea granulation plant without fluidisation air fan(s). The whole system (granulator and cooler) is operated under deep vacuum, pulling air through the system by means of the exhaust fan only. Not only does this eliminate the fluidisation air fan (and its heating of the air stream), it also creates a deep vacuum in the granulation section which enables better evaporation during the spraying of the urea melt.

Since GGT has placed the cooler on the same level as the granulator, with the same bed level as the granulator, the cooler can benefit from the deep vacuum. For the cooler, the effect is even stronger.

The cooler directly receives ambient air, since there is no fluidisation air fan heating the air by 6-9°C or more. This results in more efficient cooling and reduces the amount of cooling air.

If a fluidisation fan is required, e.g. in the case that a chiller is used on the last part of the cooler or due to ambient design conditions, GGT uses a low pressure fluidisation air fan that heats up the air by no more than 3°C. The purpose of this fan is to compensate for the pressure drop caused by the chiller. The heating of the fan can help to dry out the chilled air.

Patented double temperature scrubbing system

The deep vacuum system is most attractive when the pressure drop over the ducting, granulator/cooler and scrubbers is limited to a minimum. Therefore, GGT has designed and patented the double temperature scrubbing system involving low pressure drop horizontal type scrubbers that are able to capture very fine dust particles by condensation of water on the dust particles.

The double temperature scrubbing process can only be realised by using two separate scrubbers, one for the granulator and one for the cooler.

The low pressure drop over the system is made possible thanks to the use of Mistrix BLUeFil high efficiency mist eliminators. The close cooperation between GGT and Mistrix enables both parties to exchange knowledge and technology and offer a scrubbing system that has combined maximum efficiency with minimum pressure drop.

The BLUeFil technology enables a low pressure drop and a high efficiency since all the monofilaments are arranged at rectangular angles to the air flow to achieve the best possible separation of droplets. This unique weave (Fig. 3) stands in stark contrast to the random orientation of a wire knitted mesh.

Fig 3: **Benvitec's BLUeFil mist eliminators**

Optimising ducting

GGT has put a lot of effort into optimising the ducting throughout the urea granulation plant. Every turn or bend in an air duct creates pressure drop and may cause turbulence in the air flow. By eliminating turns where possible and limiting ducting to a minimum, pressure drop savings of over 100 mm WC are easily made.

High performance hydraulic urea melt sprayers

The in-house developed GGT Mark II hydraulic sprayer has a working pressure of 4 barg. This air-assisted urea melt sprayer has been developed during semi-industrial pilot plant tests, with the aim of lowering the atomisation air pressure to 0.3 barg. This goal has been reached and the sprayers are now being operated in full scale industrial units. The GGT liquid sprayer produces low moisture product due to the fine atomisation of the liquid, leading to very fast and efficient evaporation of the water.

The GGT Mark II sprayer not only produces very fine and homogenous droplets, but is also able to form seeds as a feed for the process in a controlled way. This seed formation can be controlled by regulating the pressure of the atomisation air, header per header and results in lower load to the crushers. In the CRG process, the crusher capacity is only half the capacity of other types of granulation units. If needed for maintenance reasons, the crusher(s) can even be bypassed without destabilising the process.

Flexibility by optional components

GGT offers the possibility to incorporate alternative cooling means to boost the cooling capacity of the fluid bed cooler. For example, water-cooled cooling plates can be added in the fluid bed. These cooling plates can be taken out of commission when ambient conditions do not require additional cooling.

The cooling plates make use of the plant cooling water circuit to boost the cooling of one or more compartments in the fluid bed cooler.

Using AirSieve technology, a stream of fine material can be extracted from the side of the cooler, at a location where the product has not yet been cooled down to end temperature. This stream is directly recycled in the stream of fines and crushed product to the granulator. ■

CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

A model approach to urea operations

Luc Dieltjens of Stamicarbon gives an overview of Stamicarbon's capabilities and products in the field of urea plant modelling as part of a three stage full life cycle philosophy for urea plants.

First-principles models have been used to support process operations in the chemical and petrochemical industries for over 40 years but hitherto only to a very limited extent in urea plants. The limited application to urea is mainly attributable to the steep rise in complexity, execution time, and other difficulties that must be addressed as the model size increases if it is to have the necessary accuracy and scope to give a reliable indication of overall economic impact on the business.

Nevertheless, urea plant models can encapsulate a large amount of process knowledge, and plant owners can benefit significantly from their use in both off-line and on-line applications. Such applications include real-time optimisation, predictive control, data reconciliation, virtual sensors, process performance monitoring, and total plant monitoring systems, to name but a few.

Stamicarbon's models are typically implemented in the ADVANCE™ and EVOLVE™ life cycle stages of a urea plant (see Fig. 1). This three-stage full life cycle approach entails continuous support through the whole lifetime of the customer's urea plant, regardless of the stage the plant is at.

LAUNCH™ comprehends all the stages in creating a reliable and profitable new urea plant and getting it up and running, from initial project development through process design, project management, training and start-up.

ADVANCE™ means the process of fine-tuning the operation by optimising production in the completed plant and maximising product quality. It allows urea producers to stay competitive with production improvements, monitoring and detection, staff training and full life-cycle support.

Fig 1: **Stamicarbon full life cycle philosophy**

Finally, EVOLVE™ means upgrading the urea plant to take advantage of improvements in technology, taking it to a new phase in its evolution.

An overview of plant modelling

Depending on the level of prior knowledge, three different classes of model can be developed:

- knowledge-driven
- data-driven
- 'gray-box' models

Knowledge-driven models, also called first-principle models, are developed on the basis of full and detailed theoretical knowledge of the underlying physical and chemical principles.

For cases in which the principles are not well understood, recourse may be had to data-driven or 'black-box' models. These empirical models are based on simple equations developed from experimental data.

In between these two extremes, there are many possible combinations of knowledge-driven and data-driven models. The theoretical knowledge offered by the simplified first-principles analysis forms the core of a so-called 'gray-box' model, while data-driven methods can compensate for those portions for which there is no adequate theoretical basis.

The Stamicarbon model is purely knowledge-driven and is consequently quite precise. The mathematical model developed includes mass and heat transfer equations, reaction kinetics, vapour-liquid equilibria, and hydrodynamic aspects, and it covers the entire plant. In total, the plant model consists of more than 5,000 linear and non-linear equations. An equation-oriented flow sheeting program developed in house is used to ensure fast solutions (typically 1 to 5 sec.) of the large and complex problems.

Difficulties in urea plant modelling

In contrast with the simple chemistry involved in urea plants, the underlying physics of mixtures containing urea and ammonium carbamate is complex. First, the feedstock to the synthesis is in supercritical state. Above the critical points, distinct liquid and gas phases do not exist, which gives rise to serious deviations in L/V-descriptions. Secondly, urea/carbamate/water solutions show large negative deviations from Raoult's law and form a maximum boiling azeotrope at a specific composition. Inflection points caused by strong non-linearity are often the source for numerical instability, as the solver algorithm cannot distinguish from which side to climb the hill. For on-line application, the model has to meet a set of performance requirements, in particular with respect to speed, robustness and flexibility; already a challenge in itself!

Off-line based modelling and data reconciliation

To ensure that the model represents the process accurately, historical distributed control system (DCS) data are collected from the operation and are subsequently used to validate the model. The measured data typically contain random errors and, less frequently, may also contain systematic errors. The role of the data reconciliation is to properly identify and correct deviations, and thus provide reliable information for updating the parameters of the model, or to spotlight systematic sensor errors.

Fig 2: **Principle of model validation**

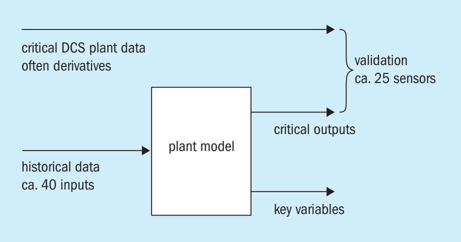


Fig 3: **Reactor temperature validation**

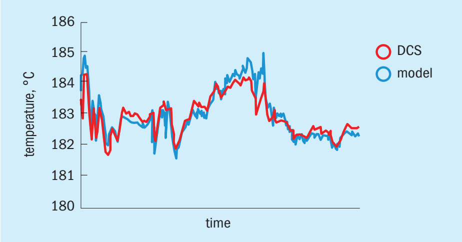


Fig 4: **Mismatch on carbamate recycle**

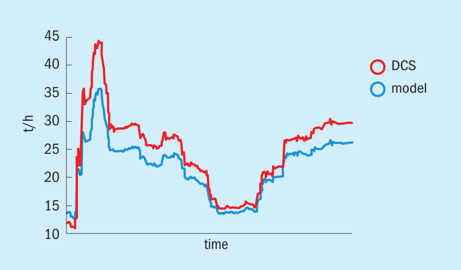
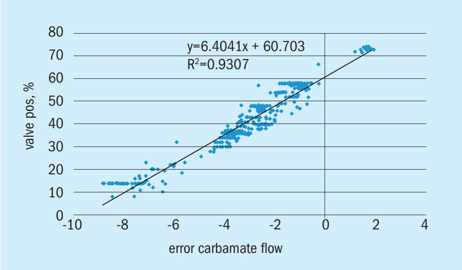


Fig 5: **Correlation between valve position and error**



The major purpose of model validation is to evaluate the accuracy and reliability of the developed plant model. For process control engineers, off-line validation can be viewed as a feedback process, the aim being to bring the model predictions into agreement with actual process measurements, in much the same way as feedback is used in process control to adjust measured values to desired target values or to within a target range (see Fig. 2). The operating conditions at key points in a urea plant can typically be set with about 40 sensor inputs, which generate about 25 meaningful feedbacks.

A validation example is illustrated in Fig. 3. The urea reactor outlet temperature is typically one of the critical variables in a urea plant. To some extent, it represents urea conversion in the reactor, assuming other interacting variables remain constant. The plot in Fig. 3 compares the temperature predicted by the model with the DCS reading over a period of two weeks. Accuracy is the level of agreement between the predicted and DCS values, while reliability is the degree to which the prediction errors vary. The accuracy of identification and reliability of validation procedures are sensitive to the size of the corresponding data sets. The required size of the historical data is typically 1-2 months; hourly averages suffice for analysis.

The concept of key variables

Key variables (KVs) characterise the technical and economic performance of the urea process. Once KVs are fixed, the operating points are fixed. KVs are normally determined by off-line sample analysis in the laboratory. One of the drivers of process modelling was to give operators and process engineers reliable and accurate estimates of key variables. This would allow them to arrive at the optimum operational point and assist them in trouble-shooting activities. As an example, the urea yield in a reactor is fully characterised by its key variables N/C, H/C, retention time, and system pressure. Only N/C can be measured in real time, whereas H/C and system pressure are determined by off-line sample analysis in the laboratory. Calculation of retention time would require a total mass balance calculation over the reactor. Specifically, real-time analysis of key variables constitutes an essential prerequisite for advanced monitoring and control of urea plants.

ADVANCE™ CONSULT is an off-line model-based service, offered by Stamicarbon. It all starts with conducting interviews with plant experts and operators, as they play a key role in fully exploiting the wealth of historical data. The experiences and expertise of those involved in day-to-day operation provide valuable insight into relevant process changes and performance of measuring devices, etc.

With a validated plant model and historical plant data, an in-depth analysis can be made from the plant operation.

The ADVANCE™ CONSULT report will typically indicate:

- evaluation of plant sensors
- plant constraints and proposed solutions.
- achieved operation relative to key variables
- low frequency oscillations and disturbance rejection (e.g. day and night rhythm).
- recommendations for improvements
- readiness for implementation of ADVANCE™ INSIGHT and EVOLVE™ OPTIMIZER.

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

A typical ADVANCE™ CONSULT analysis is illustrated in Fig. 4 which indicates a poor fit between the measured recycle carbamate flow and that predicted by the model. The HP-carbamate pump is a reciprocating type with a recycle valve. The DCS carbamate flow is calculated by:

Flow = kxRPM –recycle,
whereas
Recycle = f(Cv, ΔP).

Statistical analysis revealed a strong correlation between the error and the position of the recycle valve (see Fig. 5). The valve position is not a model input, as recycle carbamate is calculated from the heat balance over the stripper.

The ADVANCE™ CONSULT report correctly suggested that the cause was erosion on the valve trim resulting from severe cavitations. This is just one example of how off-line plant models can assist in predictive maintenance and advice on measurement deviations.

If a model has already been developed and validated for ADVANCE™ CONSULT, it can be adapted for online usage with far less trouble than developing a new model from scratch. ADVANCE™ INSIGHT is a total plant monitoring system, and successful implementation depends heavily on how closely the model represents the process as well as on the accuracy and reliability of input measurements.

Specifically, real-time analysis of KVs constitutes an essential prerequisite for advanced monitoring and perhaps later control of the urea plant.

The requirements for a successful online performance monitoring and control system include open connectivity (OPC) with DCS and other plant information systems. The plant model must be OPC-compatible, securing machine-to-machine (M2M) communication. The plant model and solver can be installed on a local device or else remotely at Stamicarbon's office, which makes the model easier to maintain.

Remote installation requires secure communication, but offers the flexibility for remote plant support.

ADVANCE™ INSIGHT supports the following features:

- key variables
- laboratory
- emission monitoring
- sensor duplication
- heat exchanger monitoring

All plant key variables can be monitored on a real-time basis.

The number of off-line analyses in the laboratory can be significantly reduced, as ADVANCE™ INSIGHT has all data on-board.

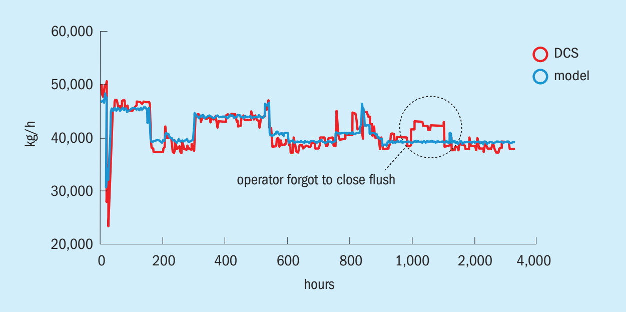
Ever more stringent regulations on ammonia emissions require reliable real-time monitoring systems. Ammonia emissions from absorbers are continuously measured with high accuracy.

Every plant sensor which is not a model input will be duplicated by the model. Having such a soft equivalent is a powerful tool for identifying sensor- and process deviations.

An optional module for heat exchangers allows critical heat exchanger monitoring. The heat transfer coefficient can be monitored closely on exchangers that are, for example, subject to fouling.

An example of ADVANCE™ INSIGHT at work is shown in Fig. 6, where the feed stream to the waste water section measured by the DCS is plotted against its model prediction. To maintain vacuum pressure in the evaporation section, the evaporator overhead line was flushed, but the flush valve was kept open for five days. The systematic deviation between model and measured data (flush is not a model input) alerted the operator to an irregularity in the plant.

Fig 6: **Gross error detection**



For Stamicarbon plants with a high-pressure falling-film condenser (HPCC), conventional plants and thermal stripping plants, the model can be configured as an accurate soft N/C meter.

In the absence of a hydrogen converter, the purge gas from the synthesis might be within flammable limits. ADVANCE™ INSIGHT is capable of detecting flammability limits, provided that the impurities in the feedstock are measured. This can be further supported with a graphical dynamic interface showing the operating point relative to the flammable area.

ADVANCE™ INSIGHT has a purely advisory function; corrective actions are left at the discretion of the operators. EVOLVE™ OPTIMIZER automates operator handling, holding the urea plant at the optimised operating point. It is the most advanced item of Stamicarbon's life cycle philosophy, being a total plant solution. It utilises the full benefits of ADVANCE™ INSIGHT but includes real-time optimisation (RTO) and model predictive control (MPC). The MPC integration is an exclusive joint effort with the company IPCOS.

The plant model is now configured as a soft sensor which generates KVs, but also as a real-time optimiser. Optimal conditions for the process at steady state are determined by the RTO, while the trajectory to be followed (as predicted with the use of a linear dynamic model, obtained through a plant step validation) is done by the MPC. On account of the inherent complexity (high degree of interactions and recycles) of a urea plant, the MPC is the perfect tool for reaching the optimal, stable operating point in a straightforward, robust way.

Once the desired stability is reached, the MPC will be used to maximise the CO_2 flow smoothly without violating any of the operating constraints, ensuring maximum attainable production at any time.

Implementing EVOLVE™ OPTIMIZER does not require any hardware changes, nor does it require a plant shut-down. The extension is limited to software only.

EVOLVE™ OPTIMIZER has been in operation at the OCI Nitrogen urea plant in Geleen, The Netherlands, since 2012, where it has resulted in a 4% increase in plant load and a 4% drop in energy consumption. ■

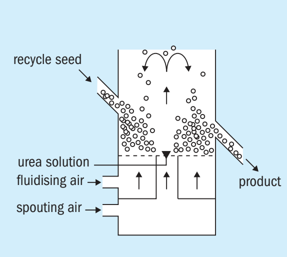
BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

From prills to granules

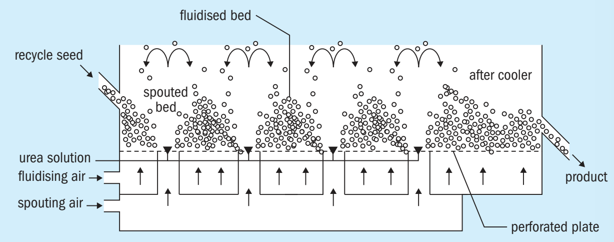
When a prilling tower limits urea unit capacity, granulation technology can be used to fatten prills, resulting in greater capacity and improved poduct quality, due to the increase in the average size of the prills and the improved prill strength. Toyo and NIIK report on their granulation technologies and how they can be applied for prill fattening.

Fig 1: **Spout-fluid bed granulation**



Source: Toyo

Fig 2: **Multi-stage spouted bed granulator**



Source: Toyo

Toyo's approach to prill fattening

Toyo's spout-fluid bed urea granulation process is mainly applied to produce granular urea from urea solution but can also use urea prills as seeds to produce granular urea in a prill fattening plant.

The Toyo spout-fluid bed granulation concept is shown in Fig. 1. The granulator consists of a spouted bed surrounded by a fluidising bed on a perforated plate, high performance spray nozzles, and spouting air pipes. Key features of the technology are reduced energy requirements and improved product quality.

In the granulator, a spouting bed is formed by an upward stream of air introduced to the spouting pipe of the granulator and a fluidised bed is formed around the spouting beds.

The air keeps the particles in suspension. Each spouted bed unit has one spray nozzle. The concentrated urea solution is sprayed using a proprietary spray nozzle into the spouted bed of urea seed particles in the granulator. The small droplets of urea solution are deposited on the circulating particles passing through the spray zone, which completely solidify before falling back onto the bed surface. The particles grow gradually by accretion of the sprayed urea droplets while this operation is repeated.

Since the air introduced for spouting and fluidising has effects on cooling and drying, the spout-fluid bed granulator functions as a cooler and drier. As a result of the drying function, 96% urea solution can be fed to the granulator to obtain a product with a moisture content of 0.3% or less.

Commercial scale urea granulator

Toyo's spout-fluid bed granulator is scaled up by proportionally increasing the number of spouting units while maintaining the capacity of the spray nozzle, flow rate of spouting air, and the geometry of the single spouting bed unit. An industrial scale granulator consists of a multi-stage spouted bed granulator as shown in Fig. 2.

According to pilot plant operation data, the higher recycle ratio gives the narrow particle size distribution of the granulator outlet granules as shown in Fig. 3. In the multi-stage spouted bed granulator, the recycle ratio of each spouted bed is inversely proportional to the number of spouted beds in series when the overall recycle ratio is constant (Fig. 4). The multi-stage arrangement produces very spherical granules with a sharp size distribution as shown in Fig. 5, even if the recycle ratio is low.

Seeds for granulation

Urea seeds required for the production of granular urea are generally supplied to the granulator by crushing the large sized urea. Prilled urea can also be utilised as seeds for granular urea production, in a urea fattening production scheme.

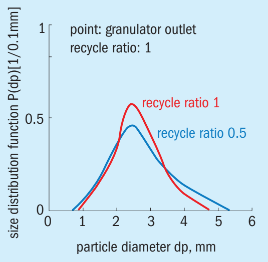
Typical urea fattening process scheme

The typical urea fattening process scheme is shown in Fig. 6, which is similar to the standard granulation process. The prilled urea is introduced to the granulator with recycle urea. The urea solution concentrated in the evaporator is fed to the spouted beds through proprietary spray nozzles to enlarge the recycle particles and prilled urea seeds in the granulator. The urea solution concentration fed to the granulator is 96-99.7% depending on the availability of the urea solution. The water in the feed urea solution is evaporated in the granulator.

The enlarged granules are cooled to a suitable temperature by fluidising air in the fuidised beds in the granulator.

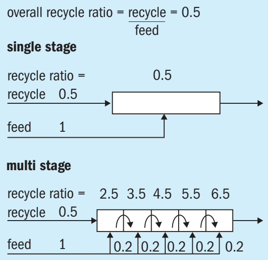
Coarse urea granules produced in the granulator are screened to separate the product size granules from undersize granules. The undersize granules are recycled back to the granulator as seed. The product size granular urea is transfer to the urea storage house after being cooled down to the appropriate temperature for storage in the product cooler.

Fig 3: **Effect of recycle ratio**



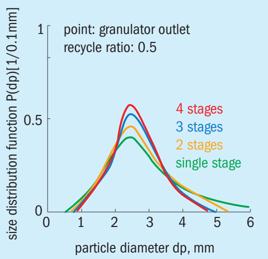
Source: Toyo

Fig 4: **No. of stages & recycle ratio**



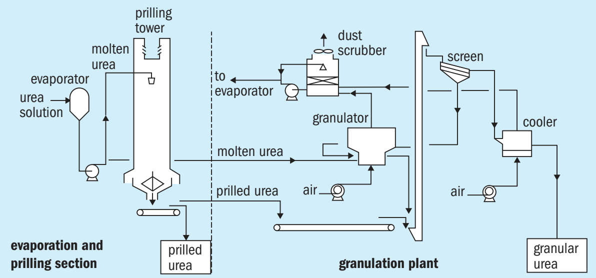
Source: Toyo

Fig 5: **No. of stages & size distribution**



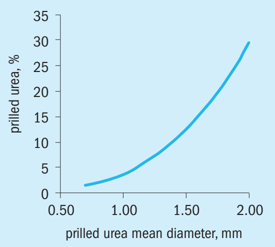
Source: Toyo

Fig 6: **Typical flow diagram of urea fattening plant**



Source: Toyo

Fig 7: **Required prill urea as seed for 3 mm granular urea production**



Source: Toyo

In the standard granulation plant, a crusher is provided to crush large sized granular urea to produce seeds for the granulation process. However, no crusher is required for the fattening plant since the seeds fed to the granulator are comparatively uniform in size. Dust generation is expected to be less with no crusher.

Prilled urea requirements for fattening plant

The prilled urea from the existing prilling tower has its own size distribution and mean diameter. In the fattening plant, the prilled urea requirement depends on the available size of the prilled urea as seeds. Fig. 7 shows the required prilled urea for a fattening plant. In the case, for example, where prilled urea of 1.4 mm is used as seed for the fattening plant to produce granular urea with 3 mm mean diameter, approximately 10% of the final production capacity is fed to the fattening plant for granular urea production. As the mean diameter of prilled urea is larger, the required amount of prilled urea is increased.

Reference plant

Mitsui Chemicals, Inc. constructed a urea granulation plant in its Osaka factory in 1983 to meet requirements in Japan. The plant produced 100 t/d of granular urea using molten urea and prilled urea as seed. This plant, stood adjacent to the existing prilling tower, and fully utilised the existing urea plant. Noteworthy features of the plant were:

- the molten urea feed pump is eliminated because the head of molten urea from the head tank on the top of the prilling tower was sufficient pressure for the spray nozzles
- no additional dust recovery system was required because the existing dust scrubber was utilised for the granulation plant.

These features resulted in a more compact plant and less investment cost compared to the installation of an additional granulation plant to the existing urea plant with prilling tower.

Unfortunately, the granulation plant was closed in the 2000s due to market conditions which made imported granular urea more competitive.

Alternative granulator

The concept for an alternative Toyo granulation process is shown in Fig. 8, in which the number of stages in the granulator is increased to produce a product with uniform size distribution based on the multi-stage concept already described, so as to deliver

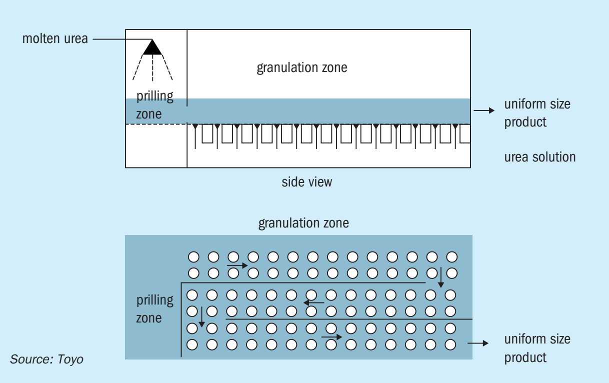
CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Fig 8: **Alternative granulator**



Source: Toyo

all granular urea to the urea storage house after cooling without screening. Spherical prilled urea with an average particle diameter of 0.4 to 0.8 mm is produced in the prilling zone and fed to the granulation zone in the proprietary granulator. Sufficient height can be easily arranged to produce small urea particles in the prilling zone of the granulator. This alternative scheme can eliminate the recycle system e.g. the screen, crusher, bucket elevator and other associated equipment. This alternative configuration has been patented in several countries including some process variations. The alternative configuration has several advantages such as lower equipment cost by eliminating the recycle system, simple operation, and small structure for granulation plant. When the prilled urea can be supplied from an existing prilling tower, the granulation zone only is provided. The alternative scheme is currently under proposal for a commercial plant.

NIIK experience in prill fattening

NIIK's high speed drum granulation (HSDG) is a universal technology that can be used for the production of urea-based fortified fertilizers such as urea with sulphur, urea with ammonium sulphate, urea with zinc and many others. Another application of HSDG technology is prill fattening (Fig. 9). For example, a urea unit can be upgraded in a small revamp to increase capacity by 15-20% with low investment cost. Larger capacity increases (>20%) of the urea finishing section (prilling, granulation) are often limited by the existing equipment and economical inefficiency, since it requires high capital costs and a longer shutdown of the entire unit.

In this situation, a space-saving drum granulator such as NIIK's HSDG can be very useful if a customer wants to increase the capacity of the prilling/granulation section. It improves urea quality and does not require large amounts of air. It's easy to install on the existing site and produces large, uniform urea prills with the properties of granulated product including their anti-caking properties.

The main feature of the HSDG unit as compared to other granulation units is a small external cycle which makes it smaller and cheaper and consequently reduces the production cost.

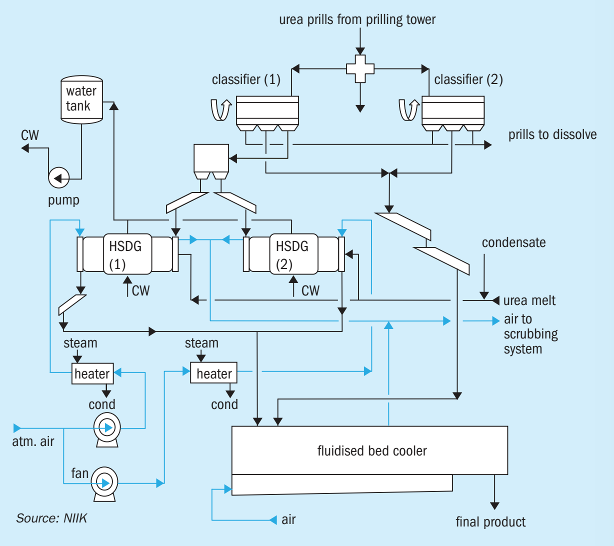
NIIK proposes an alternative method for revamping the urea finishing section in which a high speed drum granulation unit is installed (Fig. 10). This method does not interfere with the existing urea finishing section and does not require a urea unit shutdown. Its capital cost is much lower than the construction of a new prilling tower or a granulation unit.

The capacity of a single HSDG varies from 120 to 240 t/d or 5-10 t/h. The total capacity of the HSDG unit can be increased by installation of several HSDGs.

The main advantages of the HSDG unit are:

- small footprint
- easy installation at the existing urea production site
- low consumption of air
- low steam consumption for process needs
- low energy consumption and operational costs
- wide capacity range.

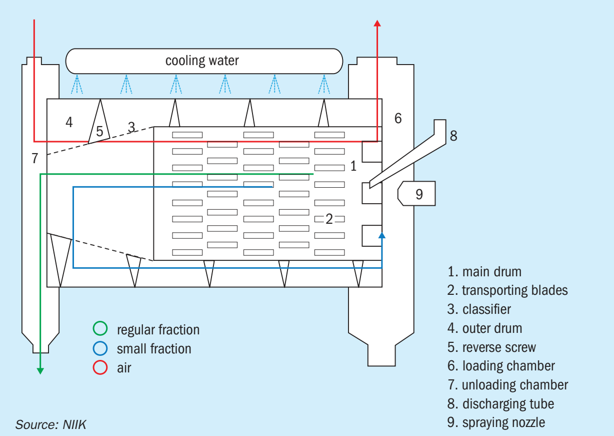
Fig 9: **HSDG unit for urea prills fattening**



Source: NIIK

Prills or granules used as seeds are delivered to the rotating drum. Due to the high rotation rate of the drum and the unique design of the internal blades, the movement of the seeds follows a parabolic curve to form a dense and uniform curtain inside the drum (Fig. 11).

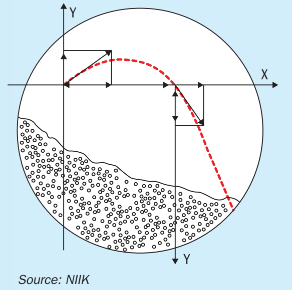
Fig 10: **High-speed drum granulator**



1. main drum
2. transporting blades
3. classifier
4. outer drum
5. reverse screw
6. loading chamber
7. unloading chamber
8. discharging tube
9. spraying nozzle

Source: NIIK

Fig 11: **Creation of curtain in the HSDG**



Source: NIIK

Table 1: **Properties of fattened urea prills produced in a HSDG**

Size distribution of fattened prills, %	
< 1 mm	1 max
1-4 mm	98 min
2-4 mm	92 min
screen residue 6 mm	n/a
Static strength of prills, kgf/prill	0.8 min.
Finished product temperature, °C	50 max.

Source: NIIK

At the same time, a solution or melt is sprayed by spraying nozzles into the front part of the drum.

As a result, all the seeds are sprayed with the solution or melt many times thus being fattened.

After fattening with the solution or melt the product is supplied to the classifier where under-size granules are removed. The finished product is discharged from the classifier to the discharge chamber and transferred for cooling. The under-size product is delivered to the main drum via a screw conveyer.

The under-size product recycled to the main drum is again sprayed with the solution or melt. The spraying and classification cycles are repeated until the granules reach the required size.

Key features of the HSDG are:

- formation of a curtain inside the drum
- classification and internal recycle
- production process intensification due to increase of the drum rotation rate.

NIIK has a continuous mode HSDG pilot unit that is used to carry out granulation trials on different types of fertilizers, to optimise the operation process and to produce samples.

The HSDG was part of the revamping concept at Kemerovo Azot aimed at a capacity increase of up to 1,700 t/d (i.e. stable output of 1,700 t/d all year round) and improved urea quality. The revamping concept also included the modernisation of the MP condensation section and vacuum condensation of the evaporation section.

In summer when the ambient temperature is higher than 15-20°C the product output from the existing prilling tower is less than 1,700 t/d (output is reduced to 1,500-1,600 t/d).

Installation of the HSDG unit can offload the prilling tower to its design capacity 1,500 t/d and makes the operation stable reducing the number of defective prills and increasing the number of on spec prills with a size of 2-4 mm. The quantity of undersize prills (<1 mm) is reduced, the number of prills with a size of 2-4 mm is increased due to fattening of the small prills under 2 mm, consequently the strength of the prills is also improved.

After the evaporation section, urea melt is divided into two streams: the first stream goes to the prilling bucket in a prilling tower to produce 1,500 t/d of finished product and the second stream is pumped to the HSDG unit to produce 100 t/d of finished product per drum granulator.

Before supply to the HSDG the melt is diluted with hot condensate to a concentration of 96-98%.

After the prilling tower the prilled urea is conveyed to the classifier, where it is sorted according to the size of the prills: under 2 mm (small prills), 2-4 mm (commodity prills), over 4 mm (big prills). Big prills are delivered for dilution, commodity prills go to the fluidised-bed cooler and about 300 t/d of small prills are supplied to the feed chamber of the HSDG unit.

The small prills are fed from the feed chamber to the drum granulator, which produces the finished product.

To maintain the required temperature in the drum granulator, the external drum surface is cooled with water and ambient air is supplied to the drum granulator.

Exhaust air from the HSDG containing ammonia and urea dust is treated in the existing wet scrubber. The urea solution from the dilution section and the scrubber is delivered to the vacuum evaporation section.

In the event that the HSDG is stopped for any reason, the prilled urea from the prilling tower is delivered to classifier (2). Prills with a size of 1-4 mm are sent to the fluidised bed cooler and further conveyed for storage or handling. Undersize and oversize prills go for dilution.

The properties of the finished product quality following the revamp of the urea unit is shown in Table 1. ■

CONTENTS
What's in issue 335
COVER FEATURE 1
Urea markets
COVER FEATURE 2
India's subsidy policy
COVER FEATURE 3
CO_2 in methanol production
COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Editor: RICHARD HANDS
richard.hands@bcinsight.com

Technical Editor: LISA CONNOCK
lisa.connock@bcinsight.com

Contributors:
LAURA CROSS, MIKE NASH

Publishing Director: TINA FIRMAN
tina.firman@bcinsight.com

Subscription rates:
GBP 425; USD 850; EUR 655

Subscription claims:
Claims for non receipt of issues must be made within 3 months of the issue publication date.

Subscriptions Manager / enquiries:
MARIETTA BESCHORNER
Tel +44 (0)20 7793 2569
Fax +44 (0)20 7793 2577
Email: marietta.beschorner@bcinsight.com
Cheques payable to BCInsight Ltd

Advertising enquiries:
TINA FIRMAN
tina.firman@bcinsight.com
Tel: +44 (0)20 7793 2567

Agents:
Japan: (also subscription enquiries)
KOICHI OGAWA
O.T.O. Research Corporation
Takeuchi Building
1-34-12 Takadanobaba
Shinjuku-Ku, Tokyo 169, Japan
Tel: +81 3 3208 7821
Fax: +81 3 3200 2889

Previous articles from *Nitrogen+Syngas* and *Nitrogen & Methanol* from 1996 to the present are available digitally in PDF format. To make a purchase, or for a list of available articles, please see: www.bcinsight.com

ISSN: 1750-6891

Design and production:
JOHN CREEK, DANI HART

Mixed Sources
Product group from well-managed forests and other controlled sources
www.fsc.org Cert no. SA-COC-001904
© 1996 Forest Stewardship Council

Printed in England by:
Buxton Press Ltd
Palace Road, Buxton, Derbyshire,
SK17 6AE

BCInsight

Published by: BCInsight Ltd
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Advertisers' index

Advertiser	Page	Contact	Fax / Email
Asian Nitrogen + Syngas 2015	53	Ms Kay Rowlands	Kay.rowlands@crugroup.com
Blasch Precision Ceramics	17	Mr Jeff Bolebruch	1 518 436 0098
Casale	9/21	Ms Rosella Gazzaniga	41 91 960 7291
CEAMAG	27	Mr Gerard Malard	33 1 30 68 93 70
CFI holding Private Limited	5	Ms Kristell Le Louarn	33 2 99 54 07 73
Clariant Produkte (Deutschland) GmbH	15	Ms Julie Reinherr	julie.reinherr@clariant.com
Eurotecnica Contractors and Engineers S.	OBC	Mr Stefano Sassi	s.sassi@eurotecnica.it
6th GPCA Fertilizer Convention	IBC	Ms Kay Rowlands	kay.rowlands@crugroup.com
Johnson Matthey	IFC	Ms Frances Lynch	44 1642 522 542
Sabin Metal Corporation	13	Mr Kevin M. Beirne	kbeirne@sabinmetal.com
Sandvik Process Systems	41	Ms Gundula Eckhardt	49 711 510 114
Schoeller-Bleckmann Nitec	49	Mr Herman Kernberger	43 2630 31919
Solex Thermal Science Inc	37	Ms Shannon Nowek	1 403 254 3501
Stamicarbon	31	Mrs Mieke Beaujean	31 46 476 3792
ThyssenKrupp Industrial Solutions	43	Ms Emily Benecke	Emily.Benecke@thyssenkrupp.com

Next issue: July/August 2015

Distribution at:
AIChE Ammonia Safety Symposium, Boston

Features in the May/June issue:

- North America's syngas boom
- African nitrogen demand
- Ammonia storage and transport
- Compression equipment in ammonia plants
- Practical solutions to corrosion problems in urea plants

Closing date for advertisement space booking is 1 July 2015
For further information and to book advertisement space contact:
Tina Firman, Publishing Director: tina.firman@bcinsight.com
Tel: +44 (0)20 7793 2567 Fax: +44 (0)20 7793 2577

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Don't forget the next issue of Nitrogen+Syngas July/August 2015

■ CONTENTS
What's in issue 335

■ COVER FEATURE 1
Urea markets

■ COVER FEATURE 2
India's subsidy policy

■ COVER FEATURE 3
CO_2 in methanol production

■ COVER FEATURE 4
Prill fattening

NITROGEN+SYNGAS
ISSUE 335
MAY-JUNE 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com