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NITROGEN+SYNGAS
ISSUE 333
JANUARY-FEBRUARY 2015

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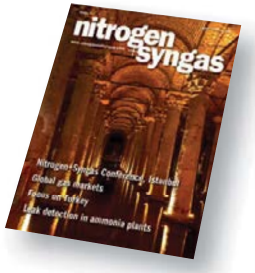
A new low



It seems strange to recall now, but just six months ago in July 2014, Brent Crude was still trading at over $110/barrel. Now it is in the high $40s/barrel – an amazing 60% fall in the last half of 2014. Even the news, just as this issue was going to press, that King Abdullah of Saudi Arabia has died has not led to the kind of panic that brings higher prices, and the indications from his successor, King Salman, are that there will be "continuity" in policy – which presumably means keeping the oil taps open in an attempt to hurt either Iran, Russia, or US tight oil producers, depending upon which conspiracy theory you adhere to, or possibly all three. The fall in the oil price is manna from heaven for consumers in China, Japan, Europe and the US, but talk that these prices may prevail for 2-3 years is a serious blow for countries like Russia, Canada, Venezuela and, lest we forget, Saudi Arabia who depend on commodity exports, although the Saudis appear to be best placed for the time being, having built up large foreign exchange reserves during the boom years in order to service deficits caused by lower oil prices. Presumably the Saudi gamble is that US tight oil producers will be most sensitive to market conditions and be forced to cut back on production. Industry sentiment is that the price drop is likely to be of the order of months rather than years, but much depends on how far and how fast oil production is cut back, and to what extent demand recovers as prices remain low. The IMF has suggested that this run of low oil prices might add another 1% plus to global GDP growth for 2015, but that may not translate into such a major boost to oil demand. High oil prices have made economies more fuel efficient, and much of the destroyed demand may be gone for the long term. If anything rescues oil markets, it will most likely be falling production, not rising demand.

> **"If anything rescues oil markets, it will most likely be falling production, not rising demand.**

The impact on the nitrogen and methanol industries is hard to gauge. Product prices for methanol tend to track oil prices, and similar for urea, at least to a degree. A lot of producers have been able to make hay over the past few years as high oil prices have kept product prices high, while low or controlled gas prices have enabled them to run at very high margins. This has led to a lot of speculative project activity, in the US as much as anywhere else, and it is a fairly safe bet that a lot of projects that have been under development may be quietly shelved over the next few months if oil prices remain low. The market is currently suffering from a degree of overcapacity, and low product prices may help the inevitable shake-out. On the other hand, the falling rouble has certainly benefited Russian nitrogen producers, and the strong dollar in general continues to be good news for producers everywhere who must pay bills in currencies not pegged to the dollar.

Longer term, in oil and perhaps in nitrogen and methanol likewise, under-investment driven by low prices may make the next peak all the sharper. Eni have said as much about the oil market recently. It remains open to doubt how long oil prices can stay below $50/bbl, and a correction back towards $80-100/bbl seems likely in the medium term. ■

Richard Hands, Editor

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Price trends

NATURAL GAS

November's cold snap in the US led to larger than expected withdrawals from gas in storage, but more mixed weather in December meant that the overall trend for stored gas was not as low as for the previous winter. Henry Hub prices, meanwhile, were clearly just as influenced by the drop in oil markets, and had reached $3.90/MMBtu by the end of November, and $3.00/MMBtu by the end of December – a price level not seen for many years. And while demand is actually down slightly, production continues to increase – 2014 overall saw a 9.7% increase in dry gas production over 2013, and US shale gas production continues to displace Canadian imports. The EIA is projecting average Henry Hub prices of $3.50/MMBtu for this winter, down $1.00/MMBtu on the previous year. The prospects for US LNG exports continue to look good.

In the UK, a milder than expected winter and the return of steady supply from Norway, again assisted by the drop in oil markets, led to spot prices at the National Balance Point falling to below 50p/therm ($7.50/MMBtu) – a 27% decrease over the end of 2013, and the lowest level for four years. Market forecasts indicate that prices may drop to 42p/therm ($6.35/MMBtu) and the future of UK shale gas exploitation – due to begin drilling in 2015 – is looking less certain.

Elsewhere in Europe, fears over an interruption to Russian gas supplies through Ukraine have weakened since Russia and Ukraine began cooperating again. The low oil price has also brought down the cost of many oil-indexed prices. Even so, Ukraine said it expected to pay $9.45/MMBtu for Russian gas in Q1 2015.

Asian LNG prices halved during 2014, and are expected to fall by another 30% this year. Spot LNG rates dropped below $10/MMBtu, although average Japanese import benchmark prices were still at $15.50/MMBtu as many were on long term contracts.

In the Middle East, meanwhile, there have been suggestions that countries should take advantage of the current market conditions to increase gas prices in order to attract more investment.

AMMONIA

Ammonia prices started to soften during November, dropping around $20/t f.o.b. at Yuzhnyy and $30/t c.fr Tampa. Diammonium phosphate producers have been suffering as demand falls in phosphate markets, and caprolactam markets have also seen lower than usual demand. The only thing that appeared to be keeping ammonia markets up was supply outages. Sorfert in Algeria had a line down, Sabic had technical issues into the start of November and Qafco later in the month, while gas shortages in Egypt kept the EBIC facility from operating in late 2014. Coupled with ongoing issues in Ukraine, gas availability issues in Trinidad and sanctions affecting output from Rossoh, there was some stability to ammonia pricing, but towards the end of November as Middle Eastern, Algerian and Black Sea capacity returned and there was little sign of new demand materialising the market began to plummet.

The Tampa price for January dropped by $80/t from $625/t to $545/t c.fr., while Yuzhnyy prices fell from $550-560/t at the end of November to just above $420/t at the end of the year. It was a similar story in the Middle East, where Arab Gulf rates dropped from $610/t f.o.b. to $470/t. At the close of December there was still no floor in sight for ammonia prices.

UREA

The urea market was generally more stable than ammonia. November saw some falls in Black Sea pricing to the $490s/t f.o.b. as ample availability from China pushed prices lower in spite of lack of availability from Ukraine and tenders for nearly 400,000 tonnes from Pakistan. Demand into South America and Southeast Asia was below expectations, and Middle East prices dropped accordingly towards $305/t f.o.b. However, towards the end of the month, significant buying from India helped to lift markets again by mopping up some of the huge Chinese surplus. China is believed to have exported 2 million tonnes in November, of which 1.2 million tonnes went to India.

Markets had been waiting to see what would happen with Chinese export taxes, and in December it was announced that for 2015 there would be a flat tax of Rmb 80/t, as widely trailed and expected, which should at least help to even out the year by removing the glut that floods the market during Chinese 'export season'. This did at least reassure those looking for January tonnages about availability.

Even so, December saw something of a recovery in markets, with little availability from Egypt and improved domestic demand in the FSU. Black Sea prills moved back to $320/t during the month, and granular was about another $15/t higher.

The market for granular urea in the US also saw a pick up towards the end of December, with New Orleans barge rates moving towards $335/st f.o.b. This also helped increase asking prices in Brazil, where buyers were having to pay $360/t c.fr, and there was a knock-on effect as Middle Eastern prodcers covered US sales. ■

Table 1: Price indications

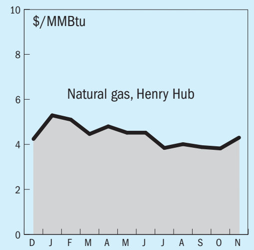
Cash equivalent	mid-Nov	mid-Sept	mid-July	mid-May
Ammonia ($/t)				
f.o.b. Caribbean	615	530	480	500
f.o.b. Arab Gulf	635	583-600	440-460	465-513
c.fr N.W. Europe	650-710	570-620	507-527	562-594
c.fr India	555-630	550-570	485-537	500-550
Urea ($/t)				
f.o.b. bulk Black Sea	315-318	318-325	290-307	300-305
f.o.b. bulk Arab Gulf*	307-320	335-360	305-318	285-290
f.o.b. bulk Caribbean (granular)	340-350	350-355	345-355	350
f.o.b. bagged China	289-294	285-290	258-260	280-285
DAP ($/t)				
f.o.b. bulk US Gulf	460	480	490-511	442-445
UAN (€/tonne)				
f.o.t. ex-tank Rouen, 30%N	200-203	194-198	186-188	181-185

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

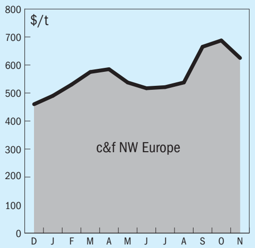
Source: Fertilizer Week

END OF MONTH SPOT PRICES

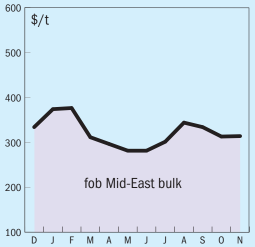
natural gas



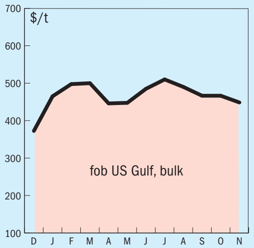
ammonia



urea



diammonium phosphate



METHANOL Mike Nash, Global Business Director, IHS Chemical

The December contract natural gas reference price was settled at $4.31/ MMBtu for Texas, and $4.37/MMBtu for Louisiana, up $0.57 from November. Overall US demand remained fairly stagnant due to seasonal factors, while production in the Americas was relatively flat. Venezuela is estimated to be running at approximately 65% on average due to larger financial and social issues. Methanex's remaining Chilean unit is down to 15% on a gas tolling arrangement, although in Trinidad, the gas curtailments of up to 30% should now be passed and are expected to return to 10-15% for 2015. OCI Beaumont will be down for debottlenecking from January-March, and Lyondell at Channelview is expected to take an outage soon to perform repairs to their furnace. Methanex's Geismar 1 plant is in start-up and will add 1.0 million t/a of capacity. The US spot market remained active; identified deals for January were in the range $1.05-1.055/gallon f.o.b. Houston, with February deals down slightly towards $1.00/gallon.

In Europe inventories are moderate and the spot market was quiet, with few bids. MiderHelm lifted its *force majeure* on methanol supply from Leuna, Germany, on 13 January, the company said. Zagros in Iran has a line down for maintenance, and Sirte Oil in Libya remains closed due to unrest at the port of Brega. Sentiment in the European methanol market is bearish and prices are trending down gently. The arbitrage between Asia and Europe is open, with prices in Rotterdam still above those in China. However, a weaker Euro has narrowed the spread between pricing. Some market participants are holding on to product, preferring to roll inventories through to 2Q in a weak market. Underlying demand is stable for conventional derivatives and slightly improved for acetic acid. Methanol demand into energy applications remains weak, against the backdrop of crude at low levels, although MTBE demand has picked up slightly, as turnarounds at US facilities have prompted exports from Rotterdam to fill South American demand. IHS Chemical post the European spot methanol price for January at €283/t f.o.b. T2 Rotterdam. February is trading at a discount to January, indicating weakness in the forward market.

In Asia, cargo prices into India CFR T1 were valued notionally at $230-240/t. Spot buying interest is modestly picking up for domestic product in China. The rest of Asia remains quiet. In Southeast Asia, reduced regional supply, with Brunei experiencing an unplanned shutdown and technical issues at Petronas, does not seem to have had a material influence on the market. Demand into key derivatives is generally stable. Spot prices were in the range $285-295/t c.fr.

In China, the average operating rate is back to 51% with several units restored to production after short unplanned shutdowns. The spot market has been volatile, but buying interest remains at a normal level with a reasonable number of spot deals concluded. Coastal inventory has been increasing, reflecting the higher level of actual product transactions. Demand into formaldehyde is stable, but DME is flat to weak as some major units have been shut down in South China. All MTO units are running very well at high rates after a difficult economic situation in November to early December when olefin prices had fallen quickly but the methanol price had not yet decreased. The current situation is improved now that the methanol price has fallen further. Demand into MMA is soft. One major MMA producer, Lucite International's 93,000 t/a unit has been shut down for a scheduled turnaround due to last about 2 months, but during this time the company will add another 80,000 t/a of capacity. Prices in East China's Jiangsu province are in the range of RMB 1,750-1,850/t and South China prices in the range of RMB 1,850-1,930/t, both down slightly. IHS posts the import price in a range of $225-235/t c.fr.

The domestic Korean market is running well with a reasonable level of transactions in the domestic currency. Demand into formaldehyde, acetic acid and MTBE is very stable without a major impact from the low global oil price. Prices were $290-295/t c.fr. In Taiwan, buying interest remains limited. Demand is stable and end-user inventory is high. C.fr prices were in the range $255-270/t. ■

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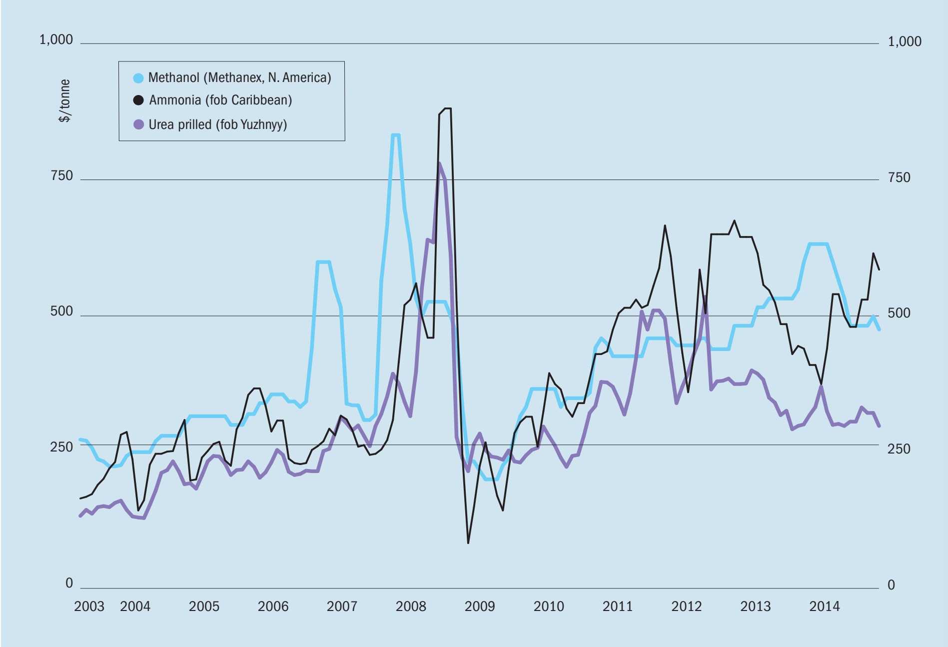
Market outlook

Historical price trends $/tonne



AMMONIA

- Ammonia prices ended 2014 on a soft note, with lower values recorded in all key markets and some buyers withholding purchases in the hope of securing further discounts.
- In the United States, phosphate producer Mosaic and ammonia supplier Yara agreed January deliveries at $545/t cfr, a cut of $80/t from the December price, which in turn was $30/t down on the November level.
- Black Sea prices have also lost ground, with recent deals reported to be netting back to below $450/t f.o.b. and firm offers indicated at $470/t f.o.b.
- OCP, Morocco is reported to have secured around 30,000 tonnes for January delivery at a price assessed at around $450/t f.o.b., some $80/t below earlier deliveries.
- Middle Eastern ammonia values have likewise tumbled, with last-done business confirmed at around $547/t f.o.b. This represented a drop of at least $50/t on earlier assessments.

UREA

- US prices have edged up in Middle Eastern and North American markets, based on trader optimism for buoyant granular urea demand. Prilled values from the FSU have also been firm, averaging around $320/t f.o.b. at year-end, up $5/t on mid-December values.
- Middle Eastern offers have been in the $335-355/t f.o.b. range, some $5-10/t above earlier sales. Freight rates have also eased, ensuring higher netbacks to the regional producers.
- Small tonnages of Baltic product have been sold in nearby markets at around $320/t f.o.b. equivalent.
- In Brazil, imported granular urea has been secured at $348/t cfr, up on earlier deals at around $343/t cfr. Trade slowed down in the final weeks of the year but is expected to pick up during January.
- The Chinese Ministry of Finance has set the export tax for urea at Rmb 80/t, equivalent to about $13/t. While higher than the Rmb 40/t applied for the low-season July-October 2014 period, the 2015 rate is down sharply on the high-season peak of Rmb 40/t plus 15% of the net export value and is a flat rate for the full year.
- Prices for prilled urea have meanwhile remained close to $290/t f.o.b., while recent sales to India have netted back to just below $285/t f.o.b. Prices for granular urea have been firm at above $310/t f.o.b., boosted by strong domestic demand for NPKs.

METHANOL

- Falling US Henry Hub gas prices, the low oil price and the start-up of Methanex's new 1.0 million t/a methanol unit at Geismar all point towards falling US methanol prices going forward.
- The European forward market is also showing weakness, although the falling value of the euro against the dollar will militate against this to a degree.
- In general there appears to be excess capacity in the market, with availability in Southeast Asia having a knock-on effect on other markets. ■

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Nitrogen Industry News

SWITZERLAND

Casale adds key fertilizer technologies to its portfolio

Casale SA has acquired Borealis' proprietary process technologies for the production of nitric acid, ammonium nitrate and urea-ammonium nitrate solution, as well as other technologies for different downstream fertilizer products including granulation technology. Some of the technologies were previously owned by Grande Paroisse/GPN Nitrogen and purchased as part of Borealis' acquisition of GPN in 2013. As part of the deal, Casale will collaborate closely with Borealis on further development of the process technologies.

"Acquiring these excellent technologies is an important step in our strategy to expand Casale's process design capabilities to downstream products directly linked with our traditional technologies, ammonia and urea, so that we can serve the nitrogen fertilizer industry in the most complete and integrated way" said Giuseppe Guarino, Casale's Chief Executive Officer. "Casale Holdings' recent acquisition of Chemoproject Nitrogen, a Czech engineering company that has built tens of nitric acid and nitrates plants, fits particularly well with this latest deal with Borealis. The specific plant engineering expertise of Chemoproject perfectly complements the process know-how we have just acquired. That means that we can now offer the fertilizer industry the most complete possible solution for nitric acid plants and their integration into nitrogen fertilizer complexes."

Federico Zardi, Casale's Chief Operational Officer, added: "This is much more than a straight technology acquisition. We have entered into a continuing partnership with Borealis under which the two companies will co-operate closely in the future development of these technologies. This is a partnership that combines the best of all worlds – Casale's innovative vision and technical excellence, which are the foundation stones of our culture, Borealis' technical and operational experience as a producer, and the inestimable benefit of having Borealis' production facilities in which to test new developments.

Markku Korvenranta, Borealis Executive Vice President Base Chemicals said that: "We remain committed to growing our fertilizer business and improving the quality of our products. Our goal is to build on our strengths in production, operations and distribution, alongside a relentless focus on efficiency, reliability and safety. Our technology partnership with Casale represents a strategic step to focus on our core markets within the European fertilizer industry, where we have ambitious growth targets."

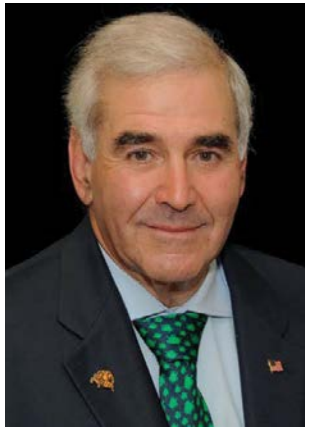
Casale founded in 1921 as Ammonia Casale, is already a leader mover in the design and refurbishment of ammonia, urea, melamine and methanol plants. With over 500 reference projects around the world, the company has acquired expertise in ammonia, methanol, urea and, more recently, in melamine production.

UNITED STATES

Tecnimont to build new ammonia-urea plant

Maire Tecnimont SpA has announced that its main subsidiary Tecnimont SpA has signed a memorandum of understanding (MoU) with Cronus Chemicals LLC which will be converted into an EPC contract to build an ammonia and urea plant located in Tuscola, Illinois. Headquartered in Chicago, Cronus is a company led by industry veterans with several decades of experience between them in the development, manufacturing and marketing of fertiliser products. Tecnimont says that the value of the EPC contract will be approximately $1.5 billion.

Cronus is seeking to build a 2,200 t/d ammonia plant and 3,850 t/d urea plant, as well as a downstream diesel exhaust fluid (DEF) facility. DEF is a urea solution used to reduce emissions in heavy duty diesel vehicles. Ammonia technology will be licensed from KBR, and urea technology from Maire Tecnimont subsidiary Stamicarbon. Project completion is expected to occur within 37 months after the EPC contract enters into force.



Andrew Sabin.

Sabin Metal marks 70th anniversary

Sabin Metal Corporation, based in East Hampton, NY is marking its 70th anniversary in 2015, although the Sabin Metal Group of Companies traces its origins back to the late 19th century. The predecessor to the current organisation was begun by the grandfather of Andrew Sabin, the company's fourth generation president. According to Sabin; "it began when my grandfather established a scrap metal business on New York's lower east side." In the early 1930s, Sabin's father – who was already working with his own father – built a lead refinery, also in New York. He subsequently partnered with another person who retired in 1945 when the present company was incorporated.

The Sabin Metal Group of Companies is composed of five independent organisations, and is the largest domestically owned, independent precious metals refining organisation in North America. Included in the Group are;

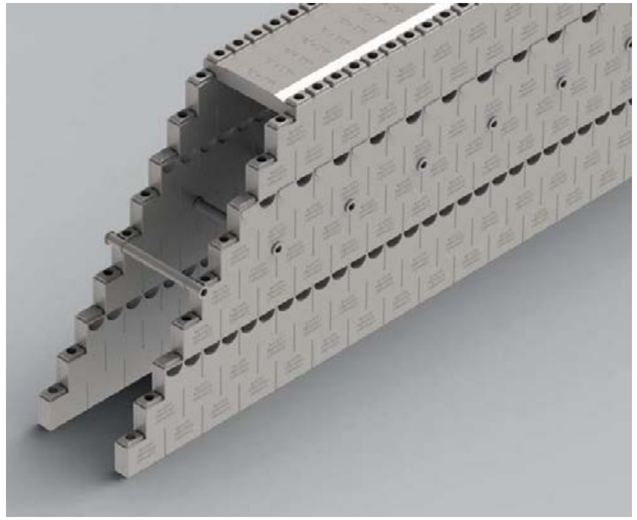
- Sabin Metal Corp., based in Scottsville, New York, considered the most sophisticated facility of its kind for safely processing precious metal-bearing materials; Sabin Metal West, a specially equipped facility for sampling large lots of precious metal-bearing spent hydrocarbon and petrochemical processing catalysts. This refinery employs dual electric arc furnace (EAF) technology which helps maximize recovery of precious metals, and also incorporates a unique "low dust" continuous sampling system for accurate sample derivation and total environmental safety and compliance.
- Sabin Metal Europe B.V., based in Rotterdam, and Sabin Metal Corp. (DMCC branch) based in Dubai, UAE are technical service divisions working with hydrocarbon, chemical, petrochemical, and nitric acid processors in Europe, Africa, and the Middle East, to recover and refine precious metals from spent catalysts and nitric acid production equipment and facilities.
- Sabin International Logistics Corp. (SILC), is a licensed hazardous waste, hazardous materials, and general commodities transporter providing global transportation and logistics for spent precious metal-bearing catalysts and other materials. The company operates its own fleet of trucks, and is also a permitted and licensed freight broker. SILC's *SA-BIN*® secure storage/shipping containers represent a unique method for quickly, conveniently, and safely storing and transporting spent precious metals-bearing catalyst materials from Sabin's customers to its processing facilities.
- SMC (Canada) Ltd., the McAlpine Mill in Cobalt, Ontario, Canada, offers capabilities and processing technologies to extract highest possible metal values from residual materials generated in refining, smelting, and milling operations.

Sabin Metal's recovery/refining facilities and sales/service offices are sited in strategic locations around the world. Sabin's gold, silver, platinum, and palladium are accepted on NYMEX/COMEX (New York and Chicago Mercantile Exchanges); Sabin's platinum and palladium are also accepted for delivery on the London/Zurich market by the London Platinum and Palladium Market (LPPM). The organisation is now entering its eighth decade of working with a worldwide customer base by providing added value services along with the peace of mind that comes from working with an environmentally responsible precious metals refiner.

KBR to revamp Mosaic ammonia plant

KBR has been awarded the license and engineering contracts to perform front-end engineering and design (FEED) for a potential expansion of Mosaic's ammonia plant in St. James, Louisiana. KBR's "lean FEED" approach will debottleneck the plant and increase Mosaic's ammonia production capacity by 20% at the plant, which is sited on the banks of the Mississippi just south of Baton Rouge. KBR's proprietary ammonia technology will be used to revamp and expand the original KBR designed plant. Additionally, KBR will provide the basic engineering design and the FEED requirements necessary to produce a final estimate prior to project approval.

"This is a significant win for KBR and we are pleased to be able to support Mosaic with both our leading technology and our technical and project delivery expertise," said Stuart Bradie, KBR president and CEO. "We look forward to developing a broader relationship with Mosaic through successful execution."



Blasch StaBlox™ *Tunnel System.*

Reliable approach to reformer flue gas tunnels

Blasch Precision Ceramics, Inc., an Albany-based ceramic technology manufacturer, says that it has developed a unique new approach to primary reformer flue gas tunnels with its *StaBlox*™ Tunnel System. According to Blasch, StaBlox allows for an extremely fast, easy installation while at the same time offering a much higher level of reliability with customizable interlocking blocks and highly engineered, mortar free expansion joints.

"Unlike traditional reformer flue gas tunnels which will typically fail as a result of the effects of multiple thermal cycles on the mortared components, and incorrect accommodation for expansion due to thermal growth, we have engineered the guesswork out of our *StaBlox* system," commented Ted Collins, Blasch sales VP. "The same base material and distributed expansion technology behind the StaBlox system has been supplied by Blasch in various high temperature combustion applications for decades now."

Because of the geometry of the blocks in the base, walls and customized structural lid of the *StaBlox* system, installation time is reduced by two thirds, with considerably less manpower required and no mortared joints.

Lawsuit alleges precious metal market price fixing

Goldman Sachs Group Inc., HSBC Holdings PLC, Standard Bank Group Ltd. , and German chemical maker BASF SE have been accused of manipulating platinum and palladium prices in a lawsuit filed in New York by a Modern Settings LLC, a Florida-based jewellery and law enforcement badge making company. The suit alleges that the four companies have colluded since 2007 to manipulate the twice-daily price "fixes" for the metals, allowing the companies to enrich themselves at the expense of other market participants, the lawsuit said.

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Agrium exits US ammonia terminals

Canadian-based Agrium says that has reached a deal to sell its two Illinois anhydrous ammonia storage and distribution terminals at Niota and Meredosia. The buyer is chemical distribution company Trammo. The two terminals, with a total capacity of 37,000t, were both inherited by Agrium through its 2006 takeover of fertilizer and chemical firm Royster Clark. Agrium said that it expects the deal, for a reported $50 million, will close in the first quarter of 2015, pending the regulatory clearances. Agrium CEO Chuck Magro said the company is "very pleased with the value received" for the two facilities, describing the sale as "another step towards simplifying our portfolio and focusing on our core businesses."

Trammo, until 2013 Transammonia AG, began as an ammonia marketing company, although it has since diversified.

Deal reached over Idaho fertilizer plant

Magnolia Nitrogen Idaho ('Magnida'), a company aiming to develop a nitrogen complex in American Falls, Idaho, has reportedly reached agreement with neighbouring firm ConAgra Foods, which had been attempting to block an air quality permit for the new facility. Magnida says that the $1-2 billion complex, which aims to produce ammonia, urea and UAN solutions remains "on track". KBR and Bechtel have been doing preliminary design work and are earmarked as EPC contractors.

CANADA

Iffco puts JV urea plant on hold

The Indian Farmers Fertiliser Cooperative (Iffco) says that its planned joint venture ammonia-urea development with Canadian famers cooperative La Coop fédérée at Bécancour in Québec has been put on hold due to increasing project costs. Preparation of preliminary plans and specifications for the project have been halted after an assessment suggested that costs could rise to more than C$2 billionn ($1.72 billion), 25% higher than the original budgeted estimate. However, the project partners have indicated that this is not necessarily the end of the line for the facility, and that the current hiatus is a "strategic pause". Iffco says that the decision will allow shareholders to review the financing, construction and completion of the project. The partners are also looking for new potential investors to share in the cost of the project.

Initial plans were for production of up to 1.6 million t/a of urea and 760,000 t/a of diesel exhaust fluid (DEF).

AUSTRALIA

Orica to build ammonia flare system

Orica has received approval from the New South Wales Government to proceed with its planned construction of three ammonia flaring systems at its facility in Kooragang Island. The three flare stacks will be of 6m, 10m and 20m respectively, according to the company. Work on the project is scheduled to commence soon and is expected to be completed in 2017-18. The project is part of a multimillion-dollar investment programme designed to improve the environmental performance of the facility. As part of the programme, ammonia storage vessels and detection and isolation systems will also be upgraded. The company has also secured approval to build a new nitric acid storage tank at the complex, which will allow the company to increase production of ammonium nitrate from 430,000 t/a to 500,000 t/a.

The plant's general manager Scott Reid said that the flaring systems are considered best practice and are used extensively in modern plants worldwide that produce and use ammonia. "This project will further improve our plant's environmental performance by capturing and flaring ammonia emissions at safety release points. This prevents them from entering the environment and in turn reduces ammonia odours."

The company says it has spent more than A$200 million in the past three years for environmental and capital upgrades at the plant, after a series of leaks and spillages, including one of ammonia and another of hexavalent chromium led to trouble with local residents and environmental regulators. Last year the company was fined A$750,000 for the 2013 ammonia spill.

Approval for new AN plant

Plans for a new A$600 million technical grade ammonium nitrate plant on Kooragang Island have been recommended for approval by the New South Wales Planning Assessment Commission (PAC). Incitec Pivot is seeking to build the new at Newcastle's Kooragang Island, where Orica already operates a similar plant (see above). In 2012 Incitec Pivot announced that it had deferred a decision on whether to go ahead with building the facility due to market conditions, but the company says that it is now seeking approval in case those conditions change.

The PAC held site visits and a public meeting in October to hear community concerns about the new plant, with safety and air quality issues to the fore given the issues with the Orica facility. However, ion its final report the PAC said that it is satisfied there will not be unacceptable adverse impacts on residents. It says the project complies with relevant government standards and will provide the nearby port of Newcastle with social and economic benefits.

INDIA

CIL signs up for coal gasification plant

Coal India Ltd (CIL), the world's largest coal mining company, has entered into two new joint ventures with the Gas Association of India Ltd (GAIL), Fertilizer Corporation of India Ltd (FCIL) and Rashtriya Chemicals and Fertilizers (RCF) for the much-delayed integrated coal gasification, fertiliser and ammonium nitrate complex at Talcher in Odisha. The first JV- GAIL Coal Gas (India) Ltd – will be led by GAIL and handle the upstream coal gasification and gas purification plant for production of syngas, with the cost now put at $480 million. Technology selection for the project is due to be complete by the end of January 2015. The second JV, Talcher Chemicals & Fertilizers Ltd, will be led by RCF, and will develop the downstream ammonia, urea, nitric acid and ammonium nitrate plants at an estimated investment of $960 million with majority stakes held by RCF and CIL. Both RCF and CIL are now reportedly undertaking pre-project activities. 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. The government is identifying a coal block near the complex for supplying feedstock to the project, and the coal ministry has started the process for allocation of the block.

Birla looking to develop new urea plant

The K. K. Birla Group is reportedly attempting to develop an ammonia-urea plant at a 200 hectare site near Jhabua in Madhya Pradesh state. Costing for the complex has been put

at $870 million. According to press reports, the Indian government has agreed to take a 20% stake in the company. K.K. Birla Group participation would presumably be via its Chambal Fertilizers and Chemicals Ltd subsidiary. No further details were available at press time.

IRAN

Talks continue on Indian JV urea plant

High level talks have been held between India and Iran on the joint proposal for an ammonia-urea plant in Iran. Indian fertilizer manufacturers Rashtriya Chemicals and Fertilizer (RCF) and Gujarat Narmada Fertilizer Co (GNFC) are both reportedly interested in the venture. The two governments are also looking into the possibility of setting up reverse special enterprise zones (SEZs) in the area of fertilizers and petrochemicals under which Indian firms involved in those sectors will be encouraged to set up plants in countries where raw material are in abundance and available at cheaper rates, while the final product will be imported back to India. Indian Minister of Chemicals and Fertilizers Ananth Kumar has said that a Joint Working Group between India and Iran in these areas with officials from both the countries will work out a roadmap for cooperation.

India has had a mixed track record in developing such plants – the Oman-India Fertilizer Company (Omifco) is a relative success story, although much wrangling was involved in its development, but a previous attempt to develop a similar joint venture plant in Iran in the 1990s foundered over pricing of feedstock.

SWEDEN

Yara to expand AN capacity

Yara International says that it will invest $220 million in expanding its technical ammonium nitrate (TAN) production capacity in Köping, Sweden. The company has secured approval from its board of directors to proceed with the expansion. As part of the project, Yara will build a new nitric acid plant, which will replace the existing facility, and which will incorporate advanced technology to improve energy efficiency and reduce greenhouse gas emissions. TAN capacity at the site will increase to 450,000 t/a.

Yara International president and CEO Torgeir Kvidal said: "with this investment, Yara further strengthens its position as the largest independent supplier of high-quality TAN globally. After the expansion, Köping will be well positioned to efficiently supply growing demand in Nordic markets, as well as continuing to supply global markets."

Expansion work is scheduled to commence in 2015 and is expected to be completed in the second half of 2017.

AZERBAIJAN

SOCAR urea plant slips to 2017

Azerbaijan's recent State Program for Industrial Sector Development for 2015-20, approved by presidential order, has re-assessed the timescale of some on-going projects, and had indicated that construction by Samsung Engineering of a 2,000 t/d urea plant for the State Oil Company of Azerbaijan (SOCAR) and the Ministry of Economy and Industry will be delayed, with the projected start-up date slipping from 2015 to 2017. Samsung was awarded the turn-key construction contract in March 2013 for the plant, which will be located in the city of Sumgait. Samsung's scope includes conducting training sessions for staff. ■

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UNITED STATES

Another MTG plant for Louisiana?

G2X Energy says that it will partner with Methanol Holdings Trinidad Limited (MHTL) to construct a world-scale methanol and downstream methanol to gasoline (MTG) facility at Lake Charles, Louisiana. The Big Lake Fuels LLC facility will produce 1.4 million t/a of commercial-grade methanol per year in the first phase of the development, with the intention to tie it into a downstream plant to convert methanol to automotive gasoline in a second phase, at some stage in the future. As part of MHTL's potential investment into G2X Energy and the Big Lake Fuels plant, G2X says that MHTL will enter into the negotiation of an exclusive off-take agreement to market the entire production of methanol from the methanol plant until the construction of the downstream MTG unit.

G2X Energy President and CEO Tim Vail said; "we look forward to partnering with MHTL and its owners Proman Holding AG and Helm AG in the construction, operation and marketing of the Big Lake Fuels plant. MHTL is a recognized leader in the production and sale of methanol worldwide. Coupling MHTL's significant presence in the existing methanol markets and their marketing, construction and operational expertise with G2X Energy's proven experience in the US natural gas market and US development and financial markets will ensure successful execution of the project and long-term production of low cost methanol."

"MHTL has been serving the U.S. market for over three decades and we, our shareholders Proman and Helm and our marketing partner Southern Chemical Corp. are very excited to announce our intention to partner with G2X Energy in this project," said Dennis Patrick, CEO of MHTL. "This strengthens our existing leadership position and gives us a competitive advantage in the growing US methanol market."

The plant will be located on a 200-acre site on the Calcasieu Industrial Canal off of the main Calcasieu Ship Channel. The site is ideally located adjacent to multiple large natural gas pipelines and industrial electricity connectivity, and affords the option to ship methanol via barge or oceangoing vessel. The site has the capability to support multiple production process trains and has been secured from the Port of Lake Charles under a long-term lease agreement.

The facility will be constructed by the Proman Group under a fixed price EPC contract. Proman, based in Wollerau, Switzerland, has extensive experience building methanol production facilities. The company has built five world-scale plants in Trinidad and Oman similar in design to the Big Lake Fuels plant. The plant will utilize steam reforming and methanol synthesis technologies from Johnson Matthey Davy Technologies Limited. The plant received its air and construction permit from the state of Louisiana on May 25. Construction is expected to begin in early 2015, after the project obtains the remaining permits and completes initial engineering. The plant is expected to require 45 bcf/year of natural gas (150 million cfd).

The move is an interesting departure for MHTL, which has just become wholly owned by Proman and Helm after a recent buyout of the shareholding of bankrupt insurance company CL Financial. Previously all of MHTL's methanol production has been based on Trinidad, and this will be the company's first venture onto the US mainland. It is a sign of the extent to which the US shale gas boom has changed the equation in the relationship between the US and Trinidad after the flight of so much of the US methanol and ammonia industry to Trinidad during the 1980s and 90s. Now it would seem, with Trinidad's gas supplies constrained by its pricing regime, the momentum is back in the opposite direction.

OCI suffers unplanned outages

OCI Beaumont says that it has restarted its methanol and ammonia units following two unplanned outages during December 2014. In the first incident a boiler feed water pump failure resulted in a halt in water supply to the methanol plant, and within a week of restart a speed indication probe failed and caused a syngas compressor to interlock and shut down. The unit was restarted after the probes were replaced. The facility has a nameplate capacity of 730,000 t/a of methanol and 265,000 t/a of ammonia.

AZERBAIJAN

AzMeCo reaches production milestone

The Azerbaijan Methanol Company (AzMeCo) said in late December that since start-up in August 2014, the company has exported 100,000 tonnes of methanol to the world markets. "Methanol was delivered to world market customers through the port of Baku and the Georgian ports of Poti and Kulevi," a company statement said; "produced methanol was delivered to the sales ports by railcars owned by AzMeCo. Since August 2014, 100,000 metric tonnes of methanol were exported to Turkey, Romania, Slovenia, Holland and Belgium." The main buyer of methanol produced at the AzMeCo plant is BP.

AzMeCo says that it has also used the Volga-Don canal for the transport of methanol for the first time, and that this is also the first time that large-scale loading of methanol has been conducted at the ports of Poti and Kulevi.

"The completion of construction of the methanol plant in Azerbaijan and its successful operation is an excellent example of support rendered to the private sector by the country's leadership," said the Chairman of the Board of Directors of the AzMeCo Nizami Piriyev. "AzMeCo methanol plant is one of the largest investments in the non-oil sector of our country. For the first time in Azerbaijan, the Company received methanol by processing of natural gas as raw material. And from an environmental point of view, this enterprise meets the latest international standards. Our company will continue to contribute to the economic development of Azerbaijan in the future."

THAILAND

Update on waste gasification project

Alter NRG Corp. has provided an update on its licensing agreement with UK-based Waste2Tricity International, which is actively developing projects in the UK and Thailand using the Westinghouse Plasma Gasification Technology owned by Alter NRG. AlterNRG says that Waste2Tricity has made "substantive progress" in the Thai market during the first year of the exclusive license. They have selected the site for the first 1,000 t/d project and completed the initial engineering study. This first project has also applied for a power purchase agreement with the Thailand government and is awaiting approval. Thailand is facing shortages of reliable base load power supply and has high power prices which are expected to generate attractive project returns for this project. Waste2Tricity has also identified a second site and is also preparing to apply for approval for a power purchase agreement on the second project.

PK Thummukgool, Country Director for Waste2Tricity International (Thailand) Ltd said; "as the exclusive licensee of the Westinghouse Plasma Technology in Thailand Waste2Tricity is pleased to be moving forward on several projects. These include large scale projects similar to those being completed by Air Products in Tees Valley, England as well as several smaller scale hazardous waste projects. The hazardous waste projects will use the turn-key Westinghouse Plasma units which have been showcased in the reference facility in Shanghai, China. The Thailand market has significant demand for power from waste and also for innovative hazardous waste destruction, reasons which make it a strong market for Waste2Tricity to continue to pursue."

QATAR

Qatar Kentz wins EPCM contract for Pearl GTL project

Qatar Kentz, a member of the SNC-Lavalin Group, has secured an engineering, procurement, construction and management (EPCM) contract for Qatar Shell's Pearl Gas-To-Liquids (GTL) onshore and offshore facilities. The four-year contract will see Kentz serve as EPCM and construction contractor for the facilities in Qatar. Kentz will manage the EPCM work for all services associated to plant changes, as well as minor, base and medium projects. It will feature project management, engineering and specialist studies, procurement and logistics, construction and commissioning management, and the execution of construction works.

Pearl GTL, which is located in Ras Laffan Industrial City, has the capacity to produce 140,000 barrels of GTL products per day. The plant also produces 120,000 barrels per day of natural gas liquids and ethane.

SNC-Lavalin Group president of oil & gas Christian Brown said: "We are thrilled to have an opportunity to strengthen our excellent relationship with Qatar Shell, which began with our first contract for Pearl several years ago. This is a highly strategic contract for us since we will be providing complete EPCM services to our client as needed for at least four years."

The Pearl GTL project was developed in two phases after major construction was completed at the end of 2010. The initial phase started up in early 2011 and exported the first commercial shipment of gasoil in June 2011. Phase two of the plant started up in early November 2011 by bringing in sour gas from offshore wells.

CHINA

UCG pilot project for Henan

SinoCoking has issued an update for investors regarding the company's Underground Coal Gasification (UCG) project at Pingdingshan in Henan province. According to the company's Chairman and CEO, Jianhua Lv, the project is on schedule and expected to start producing syngas in March 2015. Drilling of five out of six exploration wells for the first phase of the project has been completed, and the construction process will begin shortly following the drilling of the sixth exploration well. When fully functioning, UCG phase one will have the capacity to produce 60,000 m^3/h of syngas. The technology, including the proprietary compression and blending technology, allowing for storage and shipping in rail or truck containers, is patented by and exclusive to SinoCoking within Henan province.

The cost of the first phase of the operation is put at $18 million, with the expected cost of production of the syngas at $\$0.02/m^3$. The syngas produced will be used for power generation and for producing compressed natural gas (CNG), liquid natural gas (LNG) and various chemicals

"It is truly exciting to see both the above and below ground syngas facilities moving forward, and now with the addition of the CBT feature to help expand our customer base," said Mr. Lv. "We remain focused on providing clean energy solutions to promote a healthier environment for China."

AUSTRALIA

Marathon buys UCG project

Marathon Resources has signed a binding agreement to acquire ARP TriEnergy Pty Ltd. TriEnergy, Marathon's largest shareholder with a 19.99% interest, owns the Leigh Creek Energy Project in South Australia, which seeks to generate gas supplies from its coal reserves using in-situ gasification. Leigh Creek is 550km north of Adelaide with coal bearing seams between 400 and 1,500m deep.

SWEDEN

Biogas demonstration plant goes on-stream

Göteborg Energi says that GoBiGas, the Gothenburg Biomass Gasification Project, is now in operation supplying gas to the Swedish natural gas grid. GoBioGas is the first ever large-scale demonstration plant for the production of biogas via gasification of biofuels and residues from forestry. Haldor Topsoe A/S provided licensing, catalysts and engineering for the gas cleaning as well as the methanation section for the project, enabling the plant to produce substitute natural gas (SNG) by thermal gasification of forest residues as branches, roots and tops. The biomass is converted to gas with a methane content of over 95% and the plant has a capacity of 20 MW SNG.

The GoBiGas project consists of two primary phases; phase one has focused on establishing the demonstration plant now in operation while the second phase will be a full-scale commercial plant with a capacity of 80-100 MW. Until now, all Topsoe's references related to SNG have been based on coal gasification or coke oven gas. With the successful start-up of GoBiGas, however, Topsoe says that it has demonstrated and proven catalytic solutions and process technology to carry out biomass to SNG conversion as well.

"During the GoBiGas project, it was necessary to think out-of-the box and combine well-proven Topsoe SNG technologies in new ways. Göteborg Energi has been a highly competent partner in this process providing us with valuable feedback and critical assessment throughout the entire project phase, says Troels Stummann, Project Manager in Topsoe.

"The implementation of other projects remain dependent on natural gas price development and to a large degree also policy making since biomass utilization is still driven by political incentives. Nevertheless, we believe in the long-term potential of biogas as an integrated part of the future energy supply," says Lene Gottrup Barfod SNG Technology and Catalyst Manager in Topsoe.

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Leak detection in ammonia plants

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People

Gulf Petrochemical Industries Company (GPIC) president **Dr. Abdulrahman Jawahery** has been appointed as chairman of the AFA Board of Directors with effect from January 1st, 2015. Dr. Jawahery has been a prominent figure in the petrochemicals and fertilizer industries both regionally and internationally, and was first Arab member of the US National Safety Council, in addition to being a member of the NSC's Strategic Committee and Board of Trustees. He was also selected as the vice chairman and an executive member of the International Fertilizer Industry Association (IFA).

Prior to chairing the Arab Fertilizer Association (AFA), Dr. Jawahery was also an AFA board member. He is a member of Gulf Petrochemicals and Chemicals Association (GPCA) and heads its Responsible Care Committee. Dr Jawahery holds a masters degree and PhD in chemical engineering from the UK and recently was reappointed as an Ambassador of the National Examination Board in Occupational Safety and Health (NEBOSH) in the Middle East region. While president of GPIC the company has received a number of international awards in health, safety and environment (HSE) fields, namely Royal Society for the Prevention of Accidents (RoSPA) award and the 2014 Arab Award for Corporate Social Responsibility.

Dr. Abdulrahman Jawahery

Following his appointment by the state government of Gujarat, India as Principal Secretary Industries and Mines, **Atanu Chakraborty** has stepped down as chairman and managing director of Gujarat State Fertilizer Company (GSFC). His successor is S.K. Nanda.

Transammonia has combined its Ammonia Division and Fertilizers & Commodities Division into a single unit. The new Commodities Division is headed by **Christian Wendel**, latterly CEO of the Fertilizers & Commodities Division, based at Transammonia's offices in Singapore and Zurich. The management for ammonia trading is based in Tampa, USA, while international ammonia trading will be undertaken in Paris. The Tampa ammonia group is headed by **Jeff Minnis**, while **Christophe Savi** is in charge of the Paris international ammonia trading group. Transammonia Group CEO **Henk van Dalfsen** is overseeing the merger of the ammonia and fertilizer business operations from the New York head office. "The merger will allow us to increase synergies, use our global infrastructure to provide a larger portfolio of products and present ourselves to customers and suppliers as a company with different products but co-ordinated activity," he said. "We believe all of Transammonia's operations will be strengthened by the move."

Diary 2015

JANUARY

25-27

Fertilizer Americano Latino, SAO PAOLO, Brazil. 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

FEBRUARY

3-5

AFA International Fertilizer Forum, HURGHADA, Egypt
Contact: Arab Fertilizer Association Conference Section.
Tel: +20 2 2417 2347
Email: info@afa.com.eg
Web: www.afa.com.eg

23-26

Nitrogen+Syngas Conference, ISTANBUL, Turkey. 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

MARCH

23-26

IFA Global Safety Summit, VANCOUVER, Canada
Contact: IFA Conference Service, 28 rue Marbeuf, 75008 Paris, France.
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

APRIL

20-22

SynGas 2015, TULSA, Oklahoma, USA.
Contact: SynGas Association
Web: www.syngasassociation.com

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

SEPTEMBER

T.B.C.

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

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: Agrium

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Plant Manager+

Problem No. 28 How to avoid hot prills in the prill tower bottom

Hot prills can easily cause caking because heat transfer and moisture transfer take place due to the temperature difference between the hot prills and the other prills. Caking is the process of building crystal bridges between the urea particles. Caking leads to lump formation and consequently dust formation when these lumps are crushed. This all leads to poor product quality and customer complaints, but how can hot prills be avoided?

A Round Table discussion about an incident during the cleaning of a scraper (see Plant Manager+ Problem No. 27) triggered a subsequent discussion on how to avoid hot prills; hot prills obviously cause more fouling of a scraper.

Mr Mark Brouwer of UreaKnowHow.com in the Netherlands starts the Round Table discussion: The incident: During 2010 overhaul activity employees were in the prilling tower for cleaning the lumps on the scraper's arms. A steel structure with a wooden platform on top was used for safety of the employees. A big lump fell down on steel structure breaking the wooden platform. The shoulder of one employee was crashed without major injuries.

Mr Kiritkumar Patel of IFFCO in India shares his experiences: We are operating a 1,650 t/d urea plant of Stamicarbon design. The prill tower floor is equipped with a rotating scraper unit to collect and drop urea prills onto the bottom conveyor through a slit in the floor aligned to the conveyor. We observe that the urea prills get deposited on the top of the rotating arms of the scraper resulting in the need to stop the prilling unit. During summer the temperature of the urea prill is higher (approximately 105 to 110°C) than during winter (95°C depending on ambient conditions). We have to break the lumps deposited on the scraper arms at least once a week or three times in a fortnight. The frequency increases during the monsoon. Is there any solution to avoid this urea deposition on the rotating arms? How can we prevent this problem?

Mr Abdul Raouf of FFC in Pakistan contributes to the discussion: In my opinion your prill temperature at the prill tower bottom (I assume you mean this temperature) is very high and needs to be reduced to at least around 75°C maximum in the hot humid season. We are operating a 1,925 t/d Saipem plant (currently operating around 2,300 t/d) and experience the same problem. In the hot humid season, we use a prill bucket with a smaller average prill size and the cleaning frequency of the scraper arms is around once every two months. The prill temperature at the prill tower bottom is about 70-75°C while maintaining maximum possible draft through the prill tower (limit is acceptable moisture content in product). The ambient temperature here is around 45-48°C maximum and humidity about 80-85% maximum.

Mr Majid Mohammadian of OCI, The Netherlands also shares his experiences: I have the following figures from one of our plants which does not have any problems with the scraper arms:

- Prill bucket speed: 235 rpm
- Product humidity: 0.27% as average
- Maximum ambient temperature: 50°C
- Prill average size: 94% between 1-2.4 mm
- Plant capacity: 1,500 t/d.

Please let me have the above data in your plants.

Kiritkumar replies: In our plant, we have the following parameters:

- Prill bucket speed: 188 rpm
- Product humidity: 0.4% average
- Max ambient temperature: 46°C
- Prill average size: 1 to 2.4 mm: 95 %; Less than 1 mm 2 % average
- Plant capacity: 1,650 t/d

Note, we have a prill cooling system (fluidised bed cooler) downstream of the prill tower conveyor which reduces the product temperature from 110°C to 60°C.

Mr Salman Islam Shahzad of Dawood Hercules Chemicals, Ltd replies: In Dawood Hercules Chemicals Ltd, we are also facing this problem but its intensity is not as severe as indicated by you. The temperature of the prills can be reduced by producing proper draft in the prill tower (we have a natural draft prill tower). Reducing the prill size by increasing the bucket speed will also reduce the prill temperature because a high prill temperature will force the prill to absorb moisture even at low humidity. Try to reduce it below 70°C. Repeated bucket overflow due to blockage will also cause urea build-up on the scraper arms.

Majid provides more informaion: I fully agree with Salman and think that it is better to reduce the prill tower bottom temperature as much as possible (less than 70°C).

In our plant, the prill tower bottom temperature is normally around 65 to 70°C. We then reduce the temperature to 40-50°C for storage using a prill cooler. Maybe you can reduce the temperature by increasing the speed of the bucket?

Mr Easa Norozipour of Khorasan Petrochemical Company in Iran shares his experience: Urea build-up on the scraper arms is a normal phenomenon but not every week or every month, it occurs approximately once every six months and its cause is water and urea dust.

To reduce the temperature of urea at the bottom of prill tower, I suggest the following:

- Increase the bucket speed.
- Increase the air flow to the prill tower if there is induced fan and clean the fan blades every shift and change the blade angle in summer time.
- Decrease the urea melt temperature from the concentration unit as much as possible, target near 137°C.
- Check the urea melt jacket pipe steam pressure for controlling the urea melt temperature to the bucket.
- Clean the bucket holes.

To reduce the moisture content of the prills, I suggest:

- Increase the urea concentration vacuum system
- Put in service FES System to remove air humidity for the fluid bed cooler.

Mr Meer Salman Muddasar of ENGRO fertilizer in Pakistan replies: To control the prill temperature to avoid frequent cake build-up on scrapper arm, set a frequency for cleaning the top louvers of the prill tower. The draft should be well maintained. One can also install an online draft calculator at the prill tower bottom for natural draft prill towers.

Mr Ali Zama Khan of Kribhco Shyam Fertilizer Limited in India makes a suggestion: If the urea prill temperature increases, first the top louvers should be checked because the air path can be restricted due to deposition of dust on the top louvers.

Mr Pradeep Pednekar of RCF Ltd Thal in India joins the discussion: We are operating a Saipem process urea plant with a 2,300 t/d load after a capacity enhancement of 1,725 t/d design load plant. Our frequency for washing the scraper floor is once every three months. The prill temperature is 60°C. The prill tower height is 90 m with a free-fall height of 65 m and a bucket speed 380-400 rpm. The ambient air temperature is max. 40°C. There is a weekly routine schedule for changeover of bucket and crown washing (fortnight) in spite of good prill quality to avoid overflow of bucket and to have quality product. The time required for scraper floor cleaning is five hours from prilling to prilling.

Mr Prem Baboo of NFL in India adds his valuable experience: Urea deposition on the scraper arms due to an overflowing prill bucket can be avoided by increasing the prill bucket speed. The temperature of the urea melt should be 136-137°C.

The bucket capacity is also an important factor: for 3,600 t/d TX 434 series is required having about 10500 holes of 1.1 mm diameter. If the temperature of the prills is higher than 55°C then the summer bucket is used. In our plant we are producing 3,500 t/d and with the bucket using TX 434 no problem is observed. If the bucket is choked scraper arm deposition is sometimes observed within 5-6 days due to the bucket overflowing. Our normal scraper cleaning frequency is 20-22 days.

This series of discussions is compiled from a selection of round table topics discussed on the UreaKnowHow.com website. UreaKnowHow.com promotes the exchange of technical information to improve the performance and safety of urea plants. A wide range of round table discussions take place in the field of process design, operations, mechanical issues, maintenance, inspection, safety, environmental concerns, and product quality for urea, ammonia, nitric acid and other fertilizers.

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Global gas markets

Russia's pivot east, the continuing growth of LNG markets, Europe's transition to hub-based pricing and the prospect of US shale gas exports as LNG are all continuing to change the rapidly evolving global gas market.

Table 1: **Natural gas production, consumption and reserves,** 2013, billion cubic metres

	Production	Consumption	Surplus/Deficit	Reserves
United States	688	737	-49	9,300
Canada	155	104	+51	2,000
Mexico	57	83	-26	300
North America	**899**	**924**	**-25**	**11,700**
Argentina	36	48	-8	300
Trinidad	43	22	+21	400
Venezuela	28	31	-3	5,600
South/Central America	**176**	**169**	**+7**	**7,700**
Germany	8	84	-74	50
Italy	7	64	-57	100
Netherlands	69	37	+32	900
Norway	109	4	+105	2,000
Russia	605	414	+191	31,300
Turkmenistan	62	22	+40	17,500
United Kingdom	37	73	-36	200
Uzbekistan	55	45	+10	1,100
Europe/Eurasia	**1,032**	**1,065**	**+33**	**56,600**
Iran	167	162	-5	33,800
Qatar	159	26	+133	24,700
Saudi Arabia	103	103	0	8,200
UAE	56	68	-12	6,100
Middle East	**568**	**428**	**+140**	**80,300**
Algeria	79	32	+47	4,500
Egypt	56	51	+5	1,800
Nigeria	40	7	+31	5,100
Africa	**204**	**123**	**+81**	**14,200**
Australia	43	18	+25	3700
China	117	163	-46	3,300
India	30	51	-21	1,400
Indonesia	70	38	+32	2,900
Japan	*3*	117	-114	*21*
Malaysia	69	34	+35	1,100
Asia/Pacific	**479**	**591**	**-112**	**15,200**
World	**3,370**	**3,350**	**+20**	**185,700**

Source: BP

Outside of China, the predominance of natural gas as a feedstock for syngas-based industries continues, due to its relatively low cost and ease of handling – gas-based plants do not require expensive feedstock treatment and gasification front-ends, and hence require less capital investment, and gas has generally been a relatively abundant and fairly cheap source of energy. However, the worldwide marketplace for gas continues to evolve, with the spread of LNG use beginning to tie together a truly global gas market, while in places such as North America and Europe the spread of hub-based pricing has started to erode the market's previous reliance on oil-indexed pricing, which has become a major bone of contention in a period of high oil prices.

While the continuing rise of gas as a fuel for power generation has driven evermore cross-border transit, via pipeline and LNG, and the consequent disappearance of cheap 'stranded' gas, the growth in production of gas from unconventional sources; shale gas, coalbed methane, tight gas and sour gas, is a further complicating factor.

Patterns of production and consumption

Table 1 shows production and consumption figures and reserves for major gas producing and consuming countries around the world. In terms of reserves, Russia and the Middle East, mainly Qatar and Iran, are the largest holders, but compared to previous years that we have looked at global gas markets, there has been a major change at the top. Russia has had a major downgrade in its gas reserves; in 2012, BP's industry benchmark Statistical Review of World Energy cut its global natural gas reserves estimate for the first time in decades, revising Russia's still classified holdings down sharply by 25%, from 44.6 trillion cubic metres (tcm) to 32.9 tcm. BP said that it had used a conversion factor because countries of the former Soviet Union use different criteria for reporting of reserves (and keep absolute figures secret). The re-evaluation also cut reserves for Kazakhstan, Uzbekistan and Azerbaijan. The move has put Iran as now the largest holder of gas reserves in the world, and while sanctions mean that it has had issues in developing them, production continues to grow from the South Pars gas field, and the prospect of a deal over Iran's nuclear programme could lead to a significant acceleration in exploitation of those reserves.

On the production side, output from the US continues to increase. The US overtook Russia as the world's largest producer of gas in 2009, although the US is also far and away the largest consumer of gas, and still runs a slight net deficit. Elsewhere in North America, Canadian production continues to decline due to falling sour gas production in Alberta and British Columbia, which has suffered from mature fields and has been undercut by cheaper shale gas from south of the border. In the Middle East, there has been a notable ramp up of production capacity in Iran and Qatar, while Egypt's rising consumption means that within a couple of years the country may become a net importer. China has seen a major increase in gas production, much of it from unconventional sources, but at the same time there has been an even bigger increase in Chinese demand.

Eurasia as a region has a slight net surplus, but this disguises the massive transfer of gas from Russia to the countries of Western Europe, particularly Germany. Other major inter-regional transfers are from Norway to the United Kingdom (about 27 bcm in 2013) and from Norway and the Netherlands to Germany. Russia remains the world's largest exporter of gas, via pipeline to Europe, but Qatar is now the second largest, almost entirely as LNG (some is also exported via the Dolphin pipeline to other countries of the region). Norway's exports to the UK and Germany place it third in terms of exports.

Overall, the Middle East and Africa (mainly North Africa) remain the largest exporting regions, while Asia is the largest net consumer.

Russia and Europe

Looking to regional issues, one of the biggest international news stories over the past year has been Russia's conflict with the Ukraine, following the collapse of Ukraine's pro-Russian government in April 2014. Russia blamed the EU for fermenting the change of government, while the EU imposed sanctions following Russia's seizure of the Crimea and its backing for separatist rebels in the east of Ukraine. The shooting down of Malaysian Airlines flight MH-17 exacerbated concerns, and a key objective for Ukraine and Europe since then has been to try and reduce their dependence on Russian gas – Europe imports just under one third of its gas from Russia.

Gas transit hubs are changing global markets.

European gas consumption has fallen over the past few years, much of it due to a sharp decline in demand following the economic crash of 2009 and economic stagnation in the continent, as well as cheap US coal which has led to some fuel switching by power producers. European gas demand is not expected to return to its 2008 figure until 2020 at the earliest. Nevertheless, Russia gas imports to Europe actually rose to 179 bcm in 2013, and most of this is sold under long term 'take or pay' contracts. Some contracts, such as with Hungary and Lithuania, are due to expire soon, and may be renegotiated or sourced from elsewhere, but some have over 30 years to run. The Oxford Institute for Energy Studies calculates that even if these contracts are not renewed, there will still be 115 bcm of take or pay contracts in existence in 2020, and 65 bcm in 2030. This makes switching to alternate suppliers difficult unless there is a large-scale default on such contracts, something which could be a seismic event in Russian-European relations, and from which both parties are likely to shy away from as a result.

Europe has tried to switch to alternate suppliers, such as Norway, but production there seems to have plateaued, and Europe's own domestic gas producers like the Netherlands and UK are seeing falling production from very mature fields in the North Sea. North African suppliers like Libya continue to face internal turmoil, and Egypt's rising demand will see its own exports dry up. Algeria has some spare capacity but is engaged in major expansions in downstream production of ammonia. Aside from some new reserves in the Eastern Mediterranean, therefore the only major prospect for alternative supply therefore comes from either unconventional sources or LNG, but shale gas is widely distrusted in Europe and subject to bans and protests, and is not expected to play a major part in Europe's gas mix this decade, and Europe has historically not been willing to pay as much for LNG as Asian importers. Energy efficiency and renewables could make up some of the slack, but for the moment Europe seems unlikely to be able to reduce its dependence on Russian gas in the medium term future. It is notable that Europe made similar noises and efforts before to reduce dependence on Russian gas, after Russian gas disputes with Ukraine led to supply interruptions in 2006 and 2009, and little has changed since then. There is some hope of relief via the so-called Southern Gas Corridor, which will run through Azerbaijan, Georgia and Turkey to Greece, and which may be operational from 2018-19, but this accounts for only an additional 10 bcm of gas supply to Europe.

Gazprom, for its part, seems to be trying to prioritise shipments of gas to Asia and exports of LNG, just in case Europe starts trying to renege on some of its long-term contracts, and has effectively cancelled the trans-Black Sea South Stream pipeline project, which was to have bypassed Ukraine to the south and delivered gas straight to the Balkan Peninsula. Gazprom is now pushing its Eastern Gas Programme, which involves constructing over 6,500km of pipeline connecting Russia's western gas grid with both eastern pipelines and Siberian production fields, with onward transit into China. The westernmost of the two pipelines, Altai, is projected to have a capacity of 30 bcm and the easternmost 38 bcm. Russia and China signed a final agreement on the eastern line last year soon after the US and EU began imposing sanctions.

China

Chinese gas consumption is rising the fastest of any major nation. From 2008-2013,

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Chinese gas consumption has doubled, and Chinese imports of gas have risen to almost 52 bcm per year, about half by LNG and half via pipeline from Turkmenistan. The cost of importing gas into China is around $10.00-10.50/MMBtu, and the new Russian pipeline deal is believed to be for supply at around this price; a relatively hard bargain driven by China considering the production and transit costs of gas from Siberia and the cost of installing new pipeline. China has been gradually liberalising its domestic gas market, moving from government set prices and quotas to guide prices and 'cost plus' pricing, to the 2011 reforms which linked prices to fuel and LPG prices and 2013 reforms which attempted to raise gas prices nationally to reflect the cost of supply. Prices to industrial consumers now average from around $7.00/MMBtu in the west of the country up to $17/MMBtu in Shanghai. The pricing reform has encouraged developers of unconventional gas, and Chinese production of sour gas, via the south-central Sichuan basin, and coalbed methane is now climbing steadily. There is also rising shale gas production, although water availability for fracking operations remains an issue. Chinese gas production has been consequently rising quickly, although demand continues to outpace it, and coal continues to be relatively cheap and the preferred fuel for syngas production.

North America

Obviously the big story in North America is the huge boost to what had been declining gas production due to the exploitation of shale gas via horizontal drilling and hydraulic fracturing ('fracking') techniques. It is not just shale gas, though; unconventional gas production of other kinds has also hugely boosted US gas production. While shale gas now represents 35% of US gas production in the lower 48 states, tight gas represents another 26% and coalbed methane another 9% – a total of 70% of US mainland gas production now represented by unconventional production. However, it has been shale gas which has grown the fastest, and which is projected to continue gaining production share over the coming decades, coming to account for more than half of US gas production next decade. At the same time, production has grown more efficient, as the Baker-Hughes rig count continues to fall, meaning that more gas is coming from a smaller number of drilling sites.

The upshot has been that, Since 2008, the US has effectively moved into a new pricing regime. The volatile days of tight supply led to peaks in NYMEX prices of over $12.00/MMBtu, but gas prices have been low and stable for several years now, and have converged on $4.00/MMBtu.

Some of the boom in shale gas production has come from so-called 'wet' plays, where high oil prices have encouraged the production of natural gas liquids, and it remains to be seen what effect the rapid global decline in oil prices will have upon production from these sites. Nevertheless, US gas production is currently projected to exceed consumption by 2017, and to continue increasing from there. As well as increasing volumes likely to head south by pipeline into Mexico, the US is likely to become a major exporter of LNG. As well as the existing Sabine Pass plant, which is nearing completion, and which is expected to export 10 bcm/year, there are another 100 bcm/year of projects proposed/or approved, and the potential for several more. Onstream dates mostly cluster in the 2017-18 time frame. There are also three LNG plants proposed for British Columbia in Canada with a total of 24 bcm/year of capacity. If all of these plants were approved, the potential is for exports of as much as 230 bcm/year , and even a fraction of this could be severely disruptive to the global LNG market.

Africa

Although covered in more detail elsewhere in this issue, Africa is one of the few regions of the world which still has what might be called 'stranded' gas, and here it has been LNG which has been the major factor encouraging development and monetisation. Previously it was west Africa where the focus lay, with the LNG plant in Angola one of the straws in the wind and continuing expansion in Nigeria, but discoveries and development are now shifting towards east Africa, where there have been major finds offshore of Mozambique. Tanzania is another development area, and gas development could help kickstart other downstream industries. Russian oil major Lukoil has forecast that by 2020, Tanzania and Mozambique could be exporting 27 million t/a of LNG between them.

LNG

Production and consumption of liquefied natural gas reached 325 bcm in 2013, representing about 10% of the global gas market, and 32% of internationally traded gas. Both liquefaction and regasification capacity continue to grow, with the former reaching 382 bcm in 2012, and the latter 668 bcm – regasification capacity has grown faster than liquefaction, which is helping to make the market a much more liquid one. Another 95 bcm of liquefaction capacity and 127 bcm of regasification capacity are planned from 2012-2017, with Malaysia recently launching is massive floating LNG plant, and similar floating LNG plants planned for many other plances. Japan and Korea still remain the major consumers, with Japan's consumption still boosted by the slow restart of nuclear plants following the nationwide shutdown after Fukushima. Japanese LNG demand rose by 25% when its nuclear plants were shut down, and the pace of restarts has been slow, but eventually could see much of that extra LNG demand fall away again.

On the supply side, Australia is the sudden new up and comer in the world of LNG. There are 13 projects slated for the period 2014-2020, with over $70 billion of investment planned, generating an extra 84 million t/a of LNG capacity by the end of the decade, some of them fuelled by unconventional gas – in this case coalbed methane production. Australia is already the second largest exporter of LNG in the world, but still dwarfed by Qatar's 105 bcm/year, but the new projects are set to take Australia into the lead. The prospect of US and Canadian LNG exports however, competing for Pacific markets, has started to make people re-think some of the Australian investment plans.

Asia, meanwhile, continues to put the most energy into developing new import terminals. China and India are joining Japan and Korea as major importers. India's imports of LNG stood at 18 million bcm in 2013, but this is forecast to reach 65 bcm by 2020 as India's energy demand mushrooms, and Chinese LNG demand is forecast to reach 80 bcm by the end of the decade from its current 25 bcm (in 2013).

The LNG market ended up oversupplied for a few years because expected demand in the US did not materialise (due to the shale gas boom) and that, coupled with the economic crash of 2008, left a lot of overcapacity in the LNG market. The result is that there is currently something of a hiatus in LNG supply, with demand increases likely to move ahead of supply increases for a few years, and possibly leading to a tight LNG market for a couple of years until the impact of another hump of new capacity makes itself felt. New plants started up in Australia (Pluto), Angola and Algeria in 2012-14, but there were also closures in Indonesia where one plant has switched to supply the domestic market, and Alaska, and only 8 million t/a of LNG supply was added, but the large bulge of new capacity, in Australia, New Guinea, Malaysia etc, and about 83 million t/a of LNG (113 bcm/year), is scheduled for the period 2014-18. The major question for LNG markets is about the pace and volume of US LNG exports, which could end up depressing prices.

Gas pricing

Gas market deregulation, which began in the 1980s in the UK and US, is slowly beginning to spread to other places. Two major factors in this have been the development trading hubs and gas on gas competition, and the spread of LNG to so many consuming countries around the world. These give both producers and consumers a market benchmark or reference price against which price discussions can take place. A complicating factor is that many markets followed the continental European model for gas pricing formulae in including an indexation to oil prices, as gas was seen as an alternative to oil as a fuel for power plants. The run of high oil prices which ended only in late 2014 thus artificially inflated oil-indexed gas prices, which was a particular bone of contention for European consumers, as gas imported from Russia tended to be oil indexed. Likewise LNG markets initially followed an oil model and so included an oil indexation component. Only North America and parts of western Europe really experience truly free gas on gas competition, but the use of Henry Hub and the UK National Balance Point (NBP) as reference prices is changing that, providing market reference points for new contracts as they are negotiated. Continental Europe is seeing something of a 'consumer revolt' in gas pricing, and up to half of European gas is now traded at market prices rather than oil-indexed contracts, and this volume continues to rise. The fall in oil prices may have eased the pressure for change slightly, but on the other hand the Ukrainian crisis has made many European consumers look at their existing contracts and try to see if better terms can be found elsewhere, and Europe is continuing to slowly inch towards a North American model of hubs and pricing.

Meanwhile, government-fixed domestic gas prices, previously the norm in many parts of Asia and Latin America, are now gradually floating towards market rates, with LNG tending to provide a cap on gas prices. Asia still struggles without its own gas trading hub, however. Here 90% of traded gas is shipped as LNG, with only 10% travelling by pipeline, and so the most logical hub would be one that could see both import and re-export of significant LNG volumes. China, Japan, Korea and especially Singapore stand out as potential regional hubs. The preponderance of LNG demand in east Asia as opposed to other regions of the world still distorts the LNG market and prevents it from becoming a truly global market; there are still significant regional variations in delivered LNG prices. However, in a few years' time the hungry markets of Asia will have several regions competing to supply them with LNG – the Middle East, North America, Australia and Russia, and this could help move Asian LNG towards more gas on gas competition and possibly hub-based pricing. ■

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Ammonia unloading at Izmit.

PHOTO: IGSAS

Focus on Turkey

As the Nitrogen+Syngas conference moves to Istanbul this year, *Nitrogen+Syngas* looks at Turkey's role in nitrogen markets, and the prospects for the country in the years ahead.

Turkey's economy has been through something of a rollercoaster ride over the past decade or so. Following its currency and banking crisis in 2001, economic reforms halved debt: GDP ratio and brought inflation down from a high of 70% to single digits. Even after the financial crash of 2008, when the economy contracted by 5%, Turkey appeared to be in relatively good shape compared to much of the continent, and it emerged as one of the fastest growing economies in Europe, growing by 9.2% in 2010 and 8.5% in 2011, leading to ambitious plans by president Erdogan for Turkey to become one of the world's top 10 economies (it is currently ranked 16th). However, more recently this slowed dramatically to 2.1% in 2012 and only rebounded to 4% in 2013 and 3% in 2014. There have been warnings about current account deficits, public and private debt, and too great an emphasis on the construction sector.

The government has recognised this in its 10th Five-Year Plan (2014-18), and has pressed ahead with attempts to liberalise the economy, improving higher education, increasing the flexibility of labour and product markets, broadening the tax base, making the budget more flexible, and tackling the informal economy. Amongst the moves planned is a fresh round of major privatisations, mainly consisting of national infrastructure including highways, bridges, power plants and, ports, and a state-run insurance firm. In recent years, the Turkish state has withdrawn from the petrochemicals, iron, steel, alcohol, tobacco and power distribution industries, while reducing its share in a number of others including banking, insurance, telecommunications and air freight. Privatising gas transmission has yet to be completely finalised, but another on the cards is the privatisation of sulphuric acid facilities owned by Eti Maden. In the 2000s, major fertilizer firms like Tupras were privatised, and there is no doubt that the general effect has been to stimulate the Turkish economy. External investors have become slightly wary in recent years though, and not just because of economic concerns, but also regional instability, especially the civil war in Syria to the south and the growth of ISIS, and the war's potential to exacerbate Turkey's long-running struggle with Kurdish separatists in the east. Likewise moves by the government on media and the treatment of opposition movements have caused worries about what seems like an increasingly authoritarian stance by Erdogan and the AKP party.

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Fig 1: **Turkey – gas infrastructure and fertilizer industry**

Gas

Turkey is a moderately large consumer of natural gas, at around 46.3 bcm in 2013, but it produces next to nothing of its own. It imports gas mainly by pipeline from Russia, as well as some from Iran and across the Georgian border, and an additional 17% is provided by LNG imports, with Qatar, Nigeria and Algeria the largest suppliers. In recent years, though, there has been increasing interest in Turkey as a transit country to Europe in what the EU calls the 'Southern Corridor'. One of the options for the Southern Stream was Russia's South Stream pipeline, which would have run under the Black Sea from Russia to Bulgaria. However, after a long-running battle with the EU over the need for the pipeline and who would control it, and in the wake of the current EU-Russian dispute over Ukraine, Russian president Vladimir Putin announced in December 2014 that the project was over, in its planned form at least. Russia apparently intends instead to increase gas supplies to Turkey via the Blue Stream pipeline, whose capacity is being expanded from 16 bcm/year to 19 bcm/year. South Stream's attraction for Moscow was the ability to circumvent Ukraine as a transit country, but with Gazprom's pivot eastwards and the alternatives of the North Stream pipeline through the Baltic Sea to Germany, and the Yamal pipeline through Belarus and Poland, neither of which are currently running at capacity, Russia clearly feels that South Stream has become redundant.

Another major line that has been under consideration for the Southern Corridor is the Nabucco pipeline, which was originally intended to run from Erzurum in the east of Turkey (see Figure 1) to a gas hub on the Bulgarian border, and then onwards across the Balkans to Austria. The European end of this too, however, seems to have fallen by the wayside, with the Trans-Adriatic Pipeline (TAP) across Greece into Italy now the preferred option for onward transit into western Europe, and the possibility of a new hub on the Turkish-Greek border to supply Europe with gas.

Another of the major factors affecting Turkey's gas balance is the discovery of large reservoirs of offshore gas in the eastern Mediterranean. Most of the newly discovered reserves are to the southeast, off the coasts of Lebanon and Israel, in the so-called Levant Basin Province Assessment Area, but there have also been some significant discoveries around Cyprus. Estimates for reserves at the deep water Aphrodite reservoir offshore southern Cyprus were recently revised upwards by 12%, from 4.05 tcf (110 bcm) and 8.1 MMbbl of condensate previously to 4.54 tcf (130 bcm) and 9 MMbbl of condensate. Texas-based Noble Energy is responsible for developing Aphrodite Block 12, where reserves are put at 3.6-6.0 tcf, and Italy's Eni, partnered with South Korea's Kogas in an 80-20 joint venture, has recently started drilling in Cyprus Block 9. There are tentative plans for a 180km pipeline and LNG export facility which the Cypriot government would like to see built at Vassilikos on the southern coast, but Eni has said that this depends upon the results of the current drilling programme finding sufficient extra reserves to justify it. Hopes are high, as Noble has made some large discoveries further east at Tamar, with a gas resource of 9.7 tcf and Leviathan with a gas resource of more than 20 tcf. However, if the finds do not materialise, then plan B is a floating LNG plant, with pipeline options to Turkey (linking into the European network), Israel or Egypt also under discussion.

However, the area also has a number of outstanding territorial claims and disputes which the new gas discoveries have brought to the fore, in particular, Turkey's claim to northern Cyprus, which still exists as a separate, partitioned entity since the Turkish invasion of the island in 1974, although not officially recognised by any nation other than Turkey. Turkey has disputed the Republic of Cyprus' exploration of offshore blocks, and has initiated its own in the northern Cyprus area, sparking tensions between Turkey and Cyprus.

Fertilizer industry

Agriculture is an important sector of the Turkish economy, constituting 8.4% of Turkey's GDP and 10.7% of exports. Turkey has a major and mature fertilizer industry, with nitrate and phosphate capacity and downstream NPK bulk blending. On the nitrogen side, Istanbul Gubre Sanayli AS (Igsas) is one of Turkey's oldest private fertilizer producers, operating since 1971, and since 2004 owned by Yildizlar Holdings. Turkey's main primary nitrogen production takes place at Igsas' plant at Kocaeli, where there is 400,000 t/a of ammonia and 580,000 t/a of urea capacity. Yildizlar also operates 340,000 t/a of ammonium nitrate capacity at Kutahya. The other ammonia plant in Turkey is run by Gemlik Gubre Sanayli AS at Gemlik, with 300,000 t/a of capacity. Gemlik also produces calcium ammonium nitrate (capacity is 530,000 t/a).

Other nitrogen capacity is operated by Toros Agri Industry & Trade Co Ltd (Toros Tarim) at Mersin in the south of the country, where there is 600,000 t/a of CAN capacity. Toros Tarim also has 150,000 of DAP production at Mersin, and 227,000 t/a of DAP at Samsum in the north, and 330,000 t/a of MAP and DAP at Ceyhan.

Other downstream producers include Gubre Fabrikalari TAS (Gubretas), majority-owned by the Central Union of Turkish Agricultural Credit Cooperatives, which operates several hundred thousand tonnes per annum of NPK capacity at Yarimca and another smaller facility in Izmir. Bandirma Gubre Febrikalari (Bagfas) also operates diammonium phosphate and ammonium sulphate capacity at Bandirma, and Ege Gubre Sanayi AS has ammonium phosphate capacity at Aliaga.

In 2008, Gubretas made a major investment in Iran, via the Razi Petrochemical Company, in which it took a 50% stake as part of a consortium including three other Turkish firms and an Iranian company. Razi, based at Mahshar in southern Iran. It is the largest fertilizer facility in Iran, with three ammonia, three sulphuric acid, a phosphoric acid, two urea and two DAP production units in the facility. The complaex can produce 700,000 t/a of urea and 450,000 t/a of DAP.

Table 1: **Turkey's production, consumption and imports of ammonia,** '000 tonnes product

	Production	Consumption	Imports
2002	301	806	512
2003	289	728	446
2004	329	748	464
2005	380	752	398
2006	92	667	577
2007	0	576	576
2008	100	635	535
2009	0	605	605
2010	77	738	661
2011	469	969	570
2012	521	900	519

Source: IFA

Nitrate production

Table 1 shows Turkey's ammonia production, consumption and imports over the decade from 2002-2012. Although ammonia production has occasionally been crimped by gas costs, overall consumption tends to be fairly steady, to feed downstream AN/CAN, urea and MAP/DAP capacity, and the remainder has to be made up from imports, which range from 400,000 t/a to 660,000 t/a. Turkey is also a net importer of urea, to the tune of about 800,000 t/a to 1.5 million t/a. As noted, Turkey's fertilizer and agricultural markets are relatively mature, and there is not much prospect of large scale increased demand. However, while Turkey's gas situation means that there is little prospect of new ammonia capacity in the country, it continues to invest in downstream capacity. Bagfas has awarded a contract to ThyssenKrupp AG to supply a new calcium ammonium nitrate (CAN) plant, which will be integrated into the existing site on the Sea of Marmara. This will increase Bagfas' ammonia import demand. The contract is worth an approximate total of 141 million and commissioning is scheduled for early 2015. The new complex will comprise a nitric acid plant with a capacity of 1,195 t/d which can be used to produce 2,000 t/d granular 26% CAN or 1,550 t/d AN. In addition, ThyssenKrupp is also engineering and supplying an atmospheric ammonia storage tank with a capacity of 20,000 t. ■

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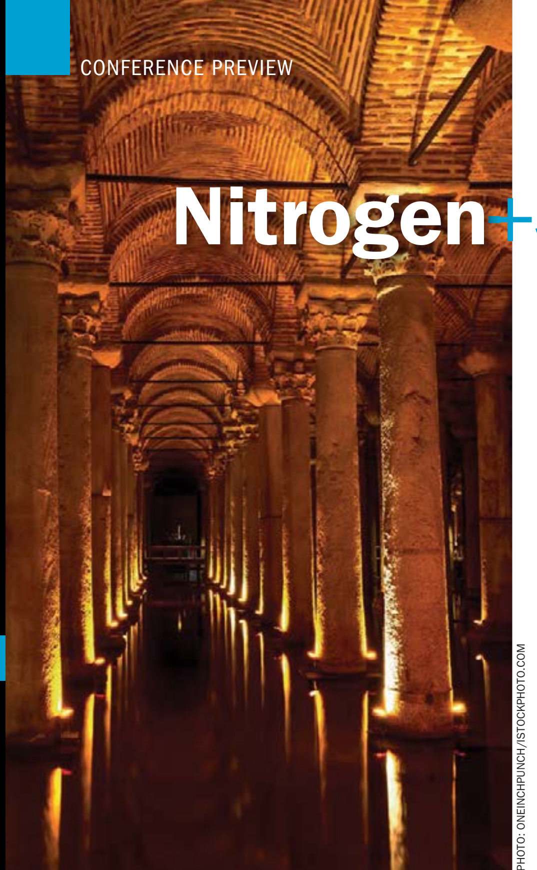

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Nitrogen+Syngas 2015

The Nitrogen+Syngas 2014 Conference and Exhibition will be held at the Hilton Bomonti, Istanbul, Turkey, from February 23rd to 26th.

The Nitrogen+Syngas Conference and Exhibition moves to Istanbul in Turkey this year. Despite short-term ups and downs in the market, long-term projections are for continuing growth in demand for ammonia, urea and other synthesis gas-based products and for investment in additional production capacity. In some regions this investment will be directed primarily at revamping existing plants in order to improve their output and efficiency, while in others the majority of investment is directed to new plants embodying the latest state-of-the-art large scale technology in order to take advantage of economies of scale, cheaper feedstocks and strategic positions for trade. Environmental and health and safety regulations also continue to drive improvements in technology, making operations cleaner, safer and more efficient.

Nitrogen+Syngas 2015 provides an international forum for operations personnel to meet with contractors, technology and equipment suppliers to share experiences and best practice, and learn about the process enhancements, technical innovation and new equipment and materials that enable them to meet the challenges of maintaining and improving plant operations. ■

MONDAY 23 FEBRUARY

PRE-CONFERENCE WORKSHOP

Operating, maintaining and revamping urea plants.

TUESDAY 24 FEBRUARY

COMMERCIAL PROGRAMME

- **Global gas outlook**
  James Henderson, Senior Research Fellow, Oxford Institute for Energy Studies
- **The outlook for nitrogen: China syndrome**
  Alistair Wallace, Senior Consultant, CRU
- **Global methanol outlook**
  Mark Berggren, Managing Director, Methanol Market Services Asia
- **Managing risks to promote investments and enhance competitiveness in the fertilizer industry**
  Anil Chandramani, Chief Investment Officer & Global Sector Lead, Chemicals & Fertilizers, International Finance Corporation
- **The geopolitical outlook for Russia and the Middle East – possible trajectories**
  Charles Hecker, Global Research Director, Control Risks
- **The FSU outlook for fertilizer demand and production**
  Mikhail Penkov, Head of Dept for Planning and Analysis, Uralchem OJSC

FRONT END SYNGAS TECHNOLOGY AND OPERATIONS

- **New generation purification catalyst technology**
  Prasant Kumar, Norbert Ringer, Clariant
- **Online asset management 24/7**
  Thomas Fortinberry, David Schmitt, Increase Performance
- **Innovative in-situ refractory repair and dry out with steam after sudden transfer line refractory**
  Syed Ali Raza Sani, Asim Rashid Qureshi, Engro Fertilizers

SYNGAS GENERATION

- **Foil supported catalysts deliver high performance in steam reformers**
  William Whittenberger, Johnson Matthey Process Technologies Inc, Dr Peter Farnell, Johnson Matthey plc
- **Extended survey of a steam reformer charged with high activity catalysts**
  Norbert Ringer, Clariant, Nenad Zecevic, Petrokemija plc
- **Novel transitional metal catalyst for synthesis gas production from CH_4/CO_2-rich gas mixtures**
  Gasan Osojnik, Petar Djinovic, Bostjan Erjavec, Albin Pintar, National Institute of Chemistry (Slovenia)

WEDNESDAY 25 FEBRUARY

METHANOL OPERATIONS

- **Experience in optimising ATR performance with high stability KATALCO catalysts**
  Kevin Mowbray, Johnson Matthey
- **Advanced process control on a methanol plant: results and benefits**
  Keiron Lennox, IPCOS UAW
- **Innovative solutions for methanol and formaldehyde production; a Chemanol/Topsoe case study**
  Khalid Moharrum, Ashok Chaudhry, Chemanol, David Bray, Haldor Topsoe AS

MATERIALS & CONSTRUCTION

- **A new metal dusting resistant nickel allow with exceptional fabricability and thermal stability**
  Vinay Deodeshmukh, Paul Crook, Mika Katcher, Jeremy Caron, Haynes International Inc
- **Receiving the right amount and right quality materials in time as promised**
  Jean-Marc Sluyters, Gemaco, Giel Notten, UreaKnowHow.com
- **High temperature hydrogen attack – recommendations of the US Safety and Hazard Board**
  Charles Thomas, Quest Integrity Group

CO_2 REMOVAL

- **Lessons learnt to extend the life and reliability of molecular sieve beds in two large ammonia plants**
  VK Arora, KPI Inc
- **Improved efficiency and lifetime reliability with new hydraulic energy recovery design**
  Andrea Gains-German, Prem Krish, Energy Recovery

NITRIC ACID CATALYSTS

- **Catalyst system for minimising total cost of ownership of a nitric acid plant**
  Oliver Henkes, Heraeus Materials Technology
- **Rewriting the definition of clean**
  Torsten Bunnagel, Johnson Matthey
- **Future improvements based on multi-layer gauze technology in ammonia oxidation**
  Christian Goerens, Sven Jantzen, Umicore AG

AMMONIA OPERATIONS

- **Detection and localisation of leaks in toxic/flammable chemicals pipelines using distributed fibreoptic sensors**
  Rob de Bont, Yara France, Daniele Inaudi, Smartec SA
- **Case studies for reliable performance in an ammonia plant**
  AP Shah, Gujarat State Fertilizers & Chemicals Ltd
- **Sharing experiences of handling various critical emergencies in a major fertilizer complex**
  Pothamsetti Harinarayana Reddy, Nagarjuna Fertilizers & Chemicals Ltd

AMMONIA REVAMPS

- **Increase of production capacity of existing ammonia plants**
  Dr Klaus Noelker, ThyssenKrupp Industrial Solutions
- **Successful ammonia plant revamping; a model for future plant modernisation**
  Sergio Panza, Casale SA
- **Leading ammonia capacity upgrade technologies**
  Mahesh Gandhi, Shamik Bhattacharya, KBR Technology

UREA TECHNOLOGY

- **Latest trends in urea process technologies**
  Mark Brouwer, UreaKnowHow.com
- **Improving energy efficiency and enhancing capacity of a urea unit through installation of a vortex mixture in the urea reactor**
  Anastasia Chausova, NIIK (R&D Institute of Urea)
- **How rigorous plant modelling can advance your urea business**
  Luc Dieltjens, Stamicarbon

UREA GRANULATION TECHNOLOGY

- **High speed drum granulation technology as a method for urea unit capacity increase and urea quality improvement**
  Nikolay Lobanov, NIIK (R&D Institute of Urea)
- **Experience from EFC urea revamp**
  Gunter Volker, ThyssenKrupp Industrial Solutions
- **Optimised fluid bed urea granulation process minimises capital investment and energy consumption and improves product quality**
  Wnag Wei, Ken Monstrey, Green Granulation Technology

THURSDAY 26 FEBRUARY

COMPRESSORS

- **Repair and modernisation of chemical compressor equipment**
  Martsynkovskyy Vasyl, TRIZ Ltd
- **Managing unforeseen oil flow across modified syngas compressor oil seals to minimise production loss**
  Ahsan Sarfaz, Rehman Hanif, Fatima Fertilizer Company Ltd
- **The latest designs and proven achievements for synthesis gas compressor drive steam turbine modernisation**
  Norihisa Wada, Kyoichi Ikeno, Hirokazu Kawashima, Makio Miromoto, Norohito Fujimura, Mitsubishi Heavy Industries

ENERGY EFFICIENCY

- **Use multi-stage integrated chilling to increase ammonia production**
  VK Arora, KPI
- **Linde Ammonia Concept for complete conversion to urea**
  Kerstin Schaller, Linde AG Engineering Division
- **Energy efficiency study and energy management system for an ammonia plant**
  D Velasquez, P Hallas, J Rodriguez, F Rossi, DVA Global Energy Services

UREA OPERATIONS

- **Operation of the world's largest single train urea plant with leaking medium pressure decomposer**
  Asim Qureshi, Engro Fertilizers Ltd
- **2005-2015; the first decade at the Omifco fertilizer complex**
  Alberto Carlo Serafero, Saipem – Snamprogetti Urea Technology
- **Failure of evaporator-separator connection in urea solution evaporation unit**
  Mohammed Badran, Misr Fertilizer Co (MOPCO)
- **Prevention of a potential catatrophic failure of a high pressure condenser in a urea plant**
  Roberto Gorza, Casale SA
- **Urea stripper prototype repairs using mirco-TIG welding**
  Muhammad Waheed, Muhammad Awan, Omair Qureshi, Engro Fertilizers Ltd
- **Practical solutions on operational trouble cases**
  Masashi Takahashi, Toyo Engineering Co

ANCILLARY OPERATIONS

- **Incorrect level configuration of steam drum can cause multiple issues at ammonia plant**
  Muhammad Azhar Malik, Majid Latif, Mohsin Mukhtar, Engro Fertilizers
- **High biological growth and air recirculation caused significant performance deterioration of cooling tower**
  Ahsan Sarfraz, Rahman Hanif, Mudassa Shah, Fatima Fertilizer Co Ltd
- **CO_2 management; from production enhancement fo energy storage**
  Dr Federico Gianluca, ALSTOM Carbon Capture GmbH

FSU CASE STUDIES

- **Optimal integration of Topsoe's ammonia, methanol and hydrogen technologies at Shchekinoazot, Russia**
  Anatoliy Surba, Shchekinoazot, Maria Yanovskaya, Svend Eric Nielsen, Haldor Topsoe
- **Tatarstan Mendeleevsk fertilizer complex ready for start-up**
  Naoya Okuzumi, Mitsubishi Heavy Industries
- **Increase of capacity and efficiency in the technological air centrifugal compressor in ammonia production**
  Aleksandr Liubimov, Entechmach RPC LLC

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Polish your process... with Polish catalysts

Perhaps most of those involved in the fertilizer business know that the Polish fertilizer industry is one of the largest in Europe, with 14 ammonia plants which have a total ammonia production capacity of over 8,000 t/d. However, probably only a few of them know that its success is based upon Polish-made catalysts for the production of synthesis gases, hydrogen and ammonia.

The increasing global demand for chemicals is driving growing demand for high-performance catalysts. This trend constitutes a major challenge for catalyst vendors. However, it need not be solely the domain of global companies, as the New Chemical Syntheses Institute (INS Puławy) and Grupa Azoty SA – Polish producers of catalysts applied in the chemical and petrochemical and other industries – are the perfect examples.

80 years of experience

The companies' beginnings in industrial catalysis date back to the 1930s, and are related to the construction of the first ammonia plant in Poland, sited at Tarnów. However, research work on catalysts and their production intensified during the 1960s, during a period of rapid development of the fertilizer industry in Poland (including the construction of new plants) and the relocation of INS's headquarters to Puławy.

New R&D centre; ammonia synthesis research

> The 1960s was a period of rapid development of the fertilizer industry in Poland.

Commercial offer

Since then, INS in Pulawy and Grupa Azoty in Tarnów have been carrying out intensive R&D work which has resulted in the development of cutting-edge technologies. Catalysts are produced in two facilities in Puławy and Tarnów with the output of high quality catalysts and sorbents complying with the highest global standards. The companies' catalyst portfolio covers:

- Purification (HDS, chlorine removal, zinc sorbent, ultrapurification),
- Steam reforming (primary, secondary reforming, autothermal reforming),
- Water-gas shift (LTS, HTS),
- Methanation (oxide and pre-reduced forms)
- Ammonia synthesis (oxide and pre-reduced forms)
- Inert materials
- Other catalysts for different applications (N_2O decomposition, vegetable oils hydrogenation and others).

Products are offered with comprehensive technical service during the entire period of catalyst operation in the plant, covering:

- supervision during loading and start-up,
- on-going monitoring and operation optimisation of catalysts,
- professional loading and unloading,
- catalyst evaluation after operation,
- return of spent catalysts.

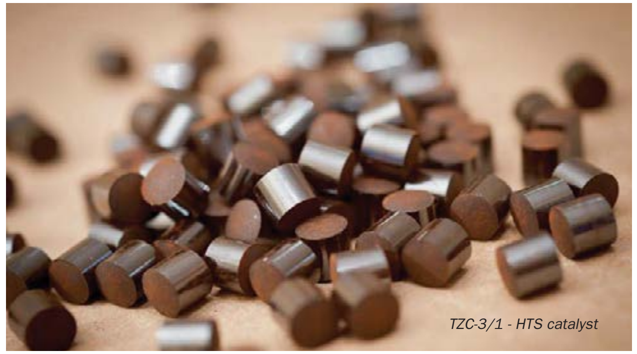
INS also carries out R&D works in the area of nitrogen technologies and offers numerous revamping solutions for existing plants focusing mainly on the improvement of energy consumption, the elimination of bottlenecks and increase in production capacity. These projects can be conducted in packages ranging from basic engineering up to turn-key implementation.

Close relationship with industry

As well as research and development work, a close relationship with the industry is a basis for success. Constantly increasing expectations of catalysts foster continuous quality improvement and directions for R&D work. INS and Grupa Azoty are able to meet these expectations thanks to a team of highly qualified specialists (50 employees including 15 PhDs) in the domain of catalysis and chemical engineering, and modern research facilities equipped with a unique apparatus allowing for product investigations and testing in the conditions similar to real plant operation in industrial conditions. Constant cooperation with top research centres in Poland and Europe allows for monitoring of current research trends in catalysis whilst close relations with industry allow for product evaluation and the specification of guidelines for further R&D works.

Latest achievement

Flagship products include steam reforming and water-gas shift catalysts. The newest catalyst for tubular steam reforming (series G 0217-7H/C) has an optimised form with seven hole ribbed rings with convex ends and, contrary to typical catalysts, its innovative formula does not contain alkali metals which lower catalyst activity. This gives G 0217-7H/C the properties of both high activity and resistance to coking, enabling the catalyst to perform at low steam:carbon ratios with conventional natural gas as well as with feedstocks containing C3-C4 species. The high porosity of the catalyst bed also results in lower pressure drop or the alternative possibility of increasing the space velocity of the process gas without a higher pressure drop as a side effect.



TZC-3/1 - HTS catalyst

The other product - HTS catalyst TZC-3/1, with its optimal formula and shape (oval tablets of 6x6 mm) allows for the achievement of a high level of catalyst bed utilisation and the required degree of conversion even with decreased catalyst volume. Its high mechanical strength provides a low and stable pressure drop across the catalyst bed through the entire period of operation, which can be over 10 years of operation in an industrial plant. Another advantage is a very low sulphur content in the catalyst, which eliminates the need for separate desulphurisation (desulphurisation is carried out during catalyst reduction). In order to meet users' expectations and fulfil strict environmental regulations and OSH regulations, the content of hexavalent chromium in the product has been lowered by over 50%.

Reliable catalysts supplier

Our top priority is to meet users' quality, process, economic and ecological requirements as well as to ensure the safe use of products. All of our products are made from the highest quality raw materials and in compliance with REACH regulations and other certified management systems. The catalysts offered have been operated for several decades in all Polish ammonia plants and exported to many countries in Europe and Asia. The very high quality of our catalysts is confirmed by numerous examples of long lifetime of catalyst operation, even for 15-18 years, and a constantly growing reference list.

For detailed information please visit our websites (www.ins.pulawy.pl and www.grupaazoty.com) or contact us: sales@ins.pulawy.pl

Novel G-0217-7H/C catalyst for tubular steam reforming

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A look east

A brief look at some of the papers presented at the Asian Nitrogen+Syngas conference in Jakarta in November.

CRU's Asian Nitrogen+Syngas conference crossed to Indonesia this year. Appropriately enough for a country with the largest ammonia and urea industry in the region, attendance at Jakarta seemed much improved on Singapore last year, with 227 delegates registered. In spite of gas shortages in some parts of the archipelago, Indonesia continues to build new capacity; Toyo gave an update on two large plants currently commissioning; Kaltim V, with 2,500 t/d of ammonia and 3,500 t/d of urea capacity, and Pusri 2b, with 2,000 t/d of ammonia and 2,750 t/d of urea, both commissioning in late 2014 or early 2015. Toyo are also building the largest single train urea plant at Port Harcourt in Nigeria, with 4,000 t/d of capacity, and say that they can go as high as 6,000 t/d!

The China syndrome

Anders Isberg of CRU gave a presentation about the global urea market. He showed how urea prices had been relatively stable during the 1990s, and unstable and generally rising during the 2000s. However, since 2011 nitrogen prices have been falling in spite of relative buoyancy in the world economy. This has mostly been down to increasing oversupply since 2009; between 2009 and 2014, around 37 million tonnes of urea supply has been added, but only 16 million tonnes of demand. Global utilisation rates have dropped from an average of 90% to around 80%. Increasing relevant, he said, was the 'China syndrome' – China now represents about 40% of global urea capacity, and domestic supply growth has outpaced demand growth to the point that a surplus has developed form 2013. In 2014 more than 10 million tonnes of urea are likely to be exported, leading to falling prices, especially since export policy was liberalised in January 2014 (and may be liberalised again from Jan 2015). China has, in essence, taken over from Ukraine as the global price setter, especially since the Russian-Ukrainian conflict has complicated the picture for Black Sea producers. Chinese production prices therefore set the price floor, estimated at about $245-250/t f.o.b. China ($205-210 ex-works). Most Chinese plants are quite marginal producers, and up to 70% of domestic industry may not be making money, but is run for other, social reasons. Nor will the situation ease soon, he said; from 2013-2018, demand will increase globally by about 20 million t/a, but capacity will increase 36 million t/a from firm projects alone, and possibly more if some more speculative projects are included, and most of this new capacity is in China. However, the stronger remnimbi vs the dollar means that Chinese producers need higher prices and face rising domestic transport costs as the rail system becomes more market oriented. Rising labour and coal costs also indicate that there will be price inflation in the floor price. Over the period 2014-19, the price of bituminous coal is expected to rise to $6/MMBtu (representing 31% of Chinese capacity) and anthracite (14%) to $7/MMBtu. Another 28% use lump/powdered anthracite with a similar cost to bituminous coal. This would indicate an f.o.b. export price from China in the region of $290/t in 2014 rising to $340-350/t in 2019, possibly helping to protect margins elsewhere in the world, such as the US.

The continued importance of the Chinese urea industry has led to a focus on being able to use cheaper, lower grade coals as a feedstock, which are not worth transporting due to their moisture content. KBR discussed this in the context of their Transport Integrated Gasifier (TRIG). The Kemper County project in Mississippi, currenly commissioning, will use this to generate power (600MW) as well as 18,000 t/a of ammonia, and 122,000 t/a of sulphuric acid from the 1% sulphur in the coal. ThyssenKrupp Industrial Solutions (formerly Uhde) also examined gasifier choices for low rank lignite coal, where a high temperature Winkler (HTW) gasifier can cope with coal with high ash content.

Side-streams

Eurotechnica, which claims 40% of the market for melamine technology, looked at the options for using melamine as a side stream to an ammonia-urea plant. Although melamine is a smaller and relatively more niche application than urea, plant sizes are rising, he noted, with 60,000 t/a now becoming a norm. Chinese urea producers have seen melamine as a way of upgrading urea in places like Mongolia that struggle with high transport costs to reach markets, as the main centres of demand for both urea and melamine are on the coast, and melamine has a higher value and a lower tonnage. If there is a bottleneck with the urea finishing section and spare ammonia and CO_2 availability, a melamine side-stream can add capacity to a urea plant, converting 0.81 t/d of ammonia into 1 t/d of higher value melamine.

Topsoe meanwhile described ways of integrating ammonia, methanol, dimethyl ether and other side streams (including sulphuric acid).

Micro-GTL

Toyo presented an update on the 'micro-GTL' technology that they presented at the Nitrogen+Syngas conference in Berlin in 2013. Large scale reserves suitable for large scale GTL production only occur in 180 gas fields worldwide, so Toyo are partnering with Veolcys, which supplies micro-channel reactors, and MODEC, the Mitsubishi Offshore Development Company, to build a floating GTL plant suitable for exploiting the more than 800 0.5 – 2.0 tcf gas fields worldwide. Velocys has been operating a demonstration unit in Brazil which has produced 125 bbl/d and performing as expected, and a number of GTL projects are under development worldwide at FEED or feasibility study stages. ■

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The Saguaro National Park, Arizona, setting for this year's meeting.

Ammonium nitrate safety

Apache Nitrogen hosted 2014's Ammonium Nitrate/ Nitric Acid meeting in Tucson, Arizona in November.

It was a move back across the Atlantic for the AN/NA meeting in 2014. The previous year's conference, in Spain, had attracted a record 409 delegates and seems to confirm that the alternate European venues are a successful strategy for the group. Nevertheless, the warmth and picturesque desert scenery of Arizona made a welcome change from a European winter!

Safety

As usual with the ammonium nitrate section of the meeting, safety and security concerns were foremost. Although he was unable to make the conference for personal reasons, the first paper, by consultant Kish described the effect of AN's low thermal conductivity, with reference to experimental work conducted by the US Bureau of Mines. Low thermal conductivity can be both a blessing or a curse. On the plus side, during fire conditions only a small outer layer may melt, and the interior of a pile of prills may stay relatively cool. It also means that day/night differential heating is unlikely to affect the quality of AN in the interior of a pile. On the other hand, it is not uncommon to get lines of hot concentrated AN solution/melt getting blocked with solid AN. When applying steam to de-block these, the heat may not penetrate sufficiently inward to melt solid AN, and prolonged heating can lead to local decomposition, escalation in temperature and pressure-build-up. High temperature gradients can lead to heating and decomposition under confined conditions, which can develop into a run-away and an explosion. A number of explosion accidents have happened on AN plants in attempts to clear choked lines; great care is needed.

Frictional heat is generated e.g. by a moving conveyor belt, in contact with heaps of AN or AN dust. This heat may not readily dissipate due to low thermal conductivity; it can lead to local heating and decomposition or fire of any combustible material present. And indeed, the frictional element appeared to be the cause of a small fire in a CAN warehouse containing 7,000 tonnes of CAN, reported by Orica. The fire occurred in a covered gallery section of conveyor line which proved difficult to access for fire crews and acted as a chimney for the fire. It was suspected that CAN had got into grease and helped clog rollers. While CAN breakdown products are not detonable, the stopped roller led to frictional heating which eventually led to fire. Orica had poor experience with smoke detection equipment during the incident. Remedies are likely to include improving ventilation, a sprinkler system and more regular inspection and maintenance of the conveyor system.

Sam Correnti of IncitecPivot detailed a recent (November 2013) accident in Mississippi involving a truck carrying AN solutions that had been forced into a precarious position on the side of a bridge after a gust of high wind had struck it at the wrong moment. Fortunately the truck was recovered without further incident.

The shadow of the accident at West in 2013 still continued to loom over the AN industry, and Noel Hsu of Orica ran through the recommendations of the Texas Fire Marshall's report, OSHA, and EPA for delegates. One of the key recommendations is that AN be stored in purpose-built facilities of non-combustible construction, away from organic materials like dust, seeds and sugar, and that local fire authorities should visit and inspect any site storing AN. Owners and operators of such facilities have a responsibility to make sure that emergency services and first responders are aware of AN hazards. The Fertilizer Institute added that steel and wooden storage bins be protected by coatings such as sodium silicate, epoxy or PVC, and that if firefighters deem it appropriate to engage an AN fire, large quantities of water should be sprayed from a distance as soon as possible.

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Some of these points were reiterated by Martin Braithwaite (Cambridge University, UK) & Ronald Peddie (Peddie Engineering , NSW, Australia, who reviewed previous AN accidents and the largely safe and stable nature of the compound, and highlighted compartmentalisation, secondary containment/ bunkering and passivation/ stabilisation as key explosion preventment/ mitigation techniques.

PotashCorp have reviewed safety and security measures at their Augusta AN plant, and detailed some of the improvements. AN product piles are now separated by 8' breeze block walls, and a zoned deluge system has been installed with IR camera monitoring and an N_2O analyser. Perimeter fencing, access gates and video monitoring have also been improved around the site.

Moisture and caking

Being hygroscopic, ammonium nitrate is prone to absorbing water and caking into solid clumps. Jaehyuk Im of ammonium nitrate producer Hu-Chems in Korea (a subsidiary of Namhae) presented an analysis of moisture content of an ammonium nitrate prill, which not only affects caking but can also control the phase transition from the phase iv rhombic crystal structure to phases iii or ii. Hu-Chems had used a microwave transmission and an electrical resistance method as well as titration, and assessed the use of the various methods, coming down on the side of the microwave transmission method, with various recommendations for procedure.

ArrMaz looked at the application of coatings to AN prills to prevent caking, cautioning that "a good coating cannot save a bad prill". The paper ran through the properties of oils, waxes, alkyl amines and organic acids, mechanisms of caking and coating techniques, and showed the impressive effects that a good anti-caking agent can have on prill properties.

Nitric acid

While ammonium nitrate issues tend to revolve around safety and security, the nitric acid half of the conference has its own set of concerns, which are typically about NOx emissions, corrosion and trying ti minimise loss of precious metal from catalyst gauzes.

Catalysts

Precious metal catalysts for ammonia oxidation are one of the greatest expenses in nitric acid production, and always one of the hottest topics for nitric acid producers. Sabin Metal Corporation presented their 'Five Myths of Precious Metals Refining'; that all precious metal refiners are the same; that cheaper is better; that you know how many ounces of precious metals you have; that you are going to get your precious metals back; and that you already know all you need to know.

Krastsvetmet of Russia have 94% of the market for platinum group metals in Russia and the CIS and are a major supplier of catalysts for ammonia oxidation within the region, but were keen on offering their product slate to a wider audience. Use of new alloys has allowed them to minimise use of precious metal, and produce a larger working surface area. Conversion rate on the UKL-7 catalyst, which has an operating pressure of 6.3 bar, is up to 94095% and on the lower pressure AK-72 95-96% (normal rate: 95%).

Apache Nitrogen's old fire truck. The company has been operating since 1920.

Umicore stressed the flexibility of multilayer catalyst gauzes for ammonia oxidation, allowing for optimisation of reaction space in three dimensions, as well as better mechanical strength and more efficient precious metal recovery.

DeNOx

Slightly further downstream, getting rid of the nitrous oxides produced in nitric acid production is also a major cost factor for producers. Yara are currently operating 23 DeNOx reactors in nitric acid plants – only one unit currently does not have catalytic NOx abatement. Most (21) use selective catalytic reduction (SCR) with ammonia as reducing agent, including 5 axial design units, 6 radial and 10 lateral units. The other two units use non-selective reactors, with natural gas/purge gas as a reducing agent. Both units use an axial design with honeycomb catalyst (PGM based). It is possible that we will see 30-50 ppm as a future NOx emission limit for existing plants, according to Yara. Today we less than 90 ppm in the majority of plants, but some are at the 100-150 ppm level. NH_3/tail gas mixing quality will be even more critical as the operational window is narrowed, and ammonia feed control will be more critical to avoid ammonia slip and ensure stable operation.

On a similar subject, Apache shared a recent experience with a violation of local NOx limits, as picked up by continuous monitoring. Apache use a honeycomb SCR system, and took steps to improve NOx/ NH_3 mixing and distribution, but problems with stratification have been persistent and investigations are continuing.

Materials

Given the corrosive nature of hot nitric acid, materials selection is always a critical issue. The worst corrosion is typically found where the highest temperatures are found, and where condensation can take place. It is a classic problem for the cooler/condenser. Sandvik Materials Technology discussed selection of materials for nitric acid service. Chromium is the key alloying element in steels, as it forms a protective oxide layer. Conversely, levels of impurities such as sulphur and phosphorus, and possibly molybdenum, can worsen problems, and careful control needs to be maintained during manufacture. Sandvik can now guarantee materials to less than 0.12mm corrosion per year. It also has a new concept of bimetallic tubing where the stainless steel is lined with zirconium for the most difficult areas.

Yara presented real world experience with corrosion in a boiler feed water preheater caused by condensation/re-boiling. The corrosion was mainly before the bottom of the outlet tube sheet where there was an inlet of cold boiler feed water. Some were heavily corroded. The remedy has been to install a pre-heater for the boiler feed water to avoid the condensation issues. ■

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Africa revisited

The past couple of years have seen several of the major nitrogen and syngas project developments planned for sub-Saharan Africa founder on project costs and gas availability, but the region retains huge potential for the development of stranded gas resources. Is it time for a fresh look at Africa?

Two years ago, Nitrogen+Syngas looked at the rapid proliferation of new ammonia-urea and methanol projects planned for sub-Saharan Africa ('Africa's gas rush', Nitrogen+Syngas 325, Sept/Oct 2013). Since then, however, it has not been plain sailing, and several of the proposed projects have been delayed or cancelled. Nevertheless, the region remains one with great potential for the development of stranded gas resources – indeed, perhaps the last major region in the world where that is still the case. In this article we revisit the projects, the potential, and the gas developments which are driving them.

Test drilling off Mozambique.

Table 1: **Gas production, consumption and reserves in selected African countries,** 2013

Country	Production (bcm)	Consumption (bcm)	Proved reserves (bcm)
Angola	0.7	0.7	360
Cameroon	0.1	0.1	135
Congo Republic	1.5	1.5	90
Equatorial Guinea	6.8	2.1	36
Gabon	0.1	0.1	28
Mozambique	3.7	0.5	4,100
Nigeria	36.1	5.3	5,100
South Africa	1.3	4.5	0.01
Tanzania	0.8	0.8	110

Source: EIA, BP

Gas is the key

New gas discoveries have been the key to this sudden interest in the region. Six of the 10 largest energy finds in 2013 were in Africa, and more than 500 companies are now exploring across the continent. North Africa has been the traditional site for gas discoveries and exploitation, with Algeria, Libya and Egypt all major producers. Attention switched to west Africa, with associated gas in Nigeria and Equatorial Guinea, and offshore gas discoveries in Angola and Namibia. But East Africa has been the hottest ticket for new discoveries in the past few years, accounting for more than 25% of all reserves added worldwide from 2020-2013, led by Mozambique in particular (where 80% of East African discoveries have taken place) and Tanzania, as well as considerable interest in Kenya, Ethiopia and Uganda. A recent International Energy Agency report put Mozambique's gas reserves at 4.5 trillion cubic metres (tcm) – on a par with Algeria (4.5 tcm) and Nigeria (5.1 tcm) – and the World Bank has suggested that they could be up to 20 tcm – higher than Turkmenistan, and almost on a par with gas-rich Qatar, putting Mozambique fourth in the world in terms of gas reserves. The International Energy Agency (IEA) estimates that Africa holds nearly 74 trillion m3 of technically recoverable natural gas reserves, nearly 10% of the world's total, and it is believed that the majority of African natural resources are still undiscovered. Table 1's figures are the most recent available, but reserves in particular are continually being revised upward for many countries.

These numbers retain a degree of speculation, of course, but indicate the level of excitement and expectation that is beginning to build around East Africa. The Rovuma Basin alone, offshore Mozambique has recently had its reserves estimate upgraded to 5.5tcm by the government. Firms exploring concessions there include a consortium led by Anadarko Petroleum (26%), which includes Mozambican state company ENH (15%), Indian groups ONGC and BRPL Ventures (20% and 10% respectively), Mitsui (20%) and Thai group PTT Exploration and Production (8.5%), and another consortium

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led by Eni (50%) which includes CNPC (20%), Korea Gas, Galp Energia of Portugal and ENH (10% each).

LNG

The flurry of new discoveries has prompted considerable activity in LNG development. Liquefied natural gas is often an engine for other downstream development, as it often relies on using 'stranded' gas which does not have a local market available, and the large investment costs are covered by long term supply contracts topped up with sales onto a large and growing international market. In remote regions development of a new LNG project also often involves the development of gas and port infrastructure which can then be used by a subsequent petrochemical project.

Historically, most of the LNG development has happened in northern Africa. There are three LNG export terminals in Algeria, two in Egypt, and one in Libya, as well as an LNG import terminal at Jorf Lasfar in Morocco. South of the Sahara, development has centred on Nigeria, where Nigeria LNG at Bonny Island operates six export trains with a capacity of 22 million t/a of methane and some condensate. More recent developments include an LNG facility at Bioko Island, off Equatorial Guinea, where a consortium run by Marathon Oil, Marubeni and Mitsui completed a 3.4 million t/a terminal in 2007, and a 5.2 million t/a export terminal at Soyo in Angola, operated by Chevron, Sonangol, BP, Eni and Total, which began operations in 2013. There are also LNG import terminals at Mombassa in Kenya, Cotonou in Benin, and Mossel Bay, South Africa. However, there are also a large number of new LNG projects under development in sub-Saharan Africa, including;

- There are three proposals for Nigeria; a seventh train at the Bonny Island plant; a company called Brass LNG which has proposed two 5 million t/a LNG trains for Brass Island, and there are also two other proposed LNG developments in Nigeria; the Brass LNG project, for 10 million t/a in two trains at Brass Island, which has Eni, NNPC, ConocoPhillips and Total as developers, and the ambitious and rather more speculative Olokola LNG project, which had discussed 25 million t/a of capacity. None of these projects have actually had a final investment decision taken on them, however.
- In Equatorial Guinea, Marathon has plans for a second LNG train at the existing site, but again has not yet made a firm commitment to develop it. There are also plans for a floating LNG export project of about 2.4 million t/a from 2019.
- GDF Suez has been trying to develop an LNG plant in Cameroon. Original studies were based around a 3.5 million t/a shore-based plant, but the project now seems to be moving to a 1.2 million t/a floating LNG plant. Bermuda-based Golar LNG says that the FLNG vessel will be completed by 2017.
- In Mozambique, the two consortia, led by Anadarko and Eni respectively, have agreed to pool their gas finds and jointly develop an LNG export project in order to reduce project development cost. The new LNG facility will have two 5.0 million t/a liquefaction trains in its first phase, with the possibility of significant expansion in future phases. Phase 1 is expected to be operational by 2018, but Mozambique's government, in its Gas Master Plan, says that it expects 10 liquefaction trains to be in operation by 2026, with a total capacity of 69 bcm/year (55 million t/a), potentially making Mozambique a top tier LNG exporter, behind Qatar, Australia, and potentially the US.
- In Tanzania, Statoil and BG Group are also looking at a joint development of their new gas find and the construction of another LNG facility, although the Tanzanian government believes that they need to find more gas in order to justify the size of the development.

The East African projects are currently attracting the most excitement, as the region is ideally situated to supply Asian LNG markets, which are forecast to be the major growth area over the next few years.

Pipelines

Pipeline developments have been few and far between, as most of the gas is developed for export out of Africa, and so African gas pipelines have mainly been from North Africa to Europe. The 680km West African Gas Pipeline allows Nigeria to export gas to Benin, Togo and Ghana, although it has suffered from a number of technical issues, sabotage and accidents. A 2,500 km trans-Saharan pipeline project to connect Nigeria to export pipeline networks to Europe has had several incarnations, including a proposal by the late Colonel Ghadaffi to connect via Libya, and an idea in development since 2002 to connect via Algeria. Nigeria seems keen to press ahead with its section of the line, but the presence of groups of Islamic rebels along the route mean that this $20 billion project is unlikely to move ahead until the security situation improves.

Downstream industries

Much of the development of sub-Saharan Africa's downstream syngas-based industries has occurred in South Africa, mainly based on coal. South Africa pioneered synthetic fuels development using its domestic coal reserves during the years of international sanctions, and Sasol is now one of the largest and most experienced users and providers of GTL/CTL technology. The company operates 165,000 barrels/day of CTL capacity at Secunda, although it put on hold in 2010 plans to develop a new 80,000 bbl/d CTL project at Mafutha in conjunction with mining group Exxaro Resources.

On the nitrogen side, Sasol's Nitro arm was founded in 1981as Sasol Fertilizers. Today the company operates a 300,000 t/a plant at Sasolburg and two trains at Secunda with another 250,000 t/a, all based on coal gasification. Sasol also has downstream capacity to manufacture nitric acid, ammonium nitrate and ammonium sulphate, and operates a 140,000 t/a methanol plant at Sasolburg, again using gasified coal as a feedstock.

AEL, formerly the African Explosives and Chemicals Industries (AECI) Group, also used to operate ammonia, urea and methanol capacity at its Modderfontein site, but these were sold to Kynoch Fertilizers in 1993, and Kynoch was itself bought by Yara in 2000, and the ageing plants were closed down. AEL still manufactures ammonium nitrate for explosives use, using ammonia sourced from Sasol, as does mining company Omnia, which has nitric acid, AN and CAN facilities at Sasolburg. Omnia recently expanded production at Sasolburg, adding a 330,000 t/a nitric acid and ammonium nitrate plant and inking ammonia supply deals with Qafco and Sasol.

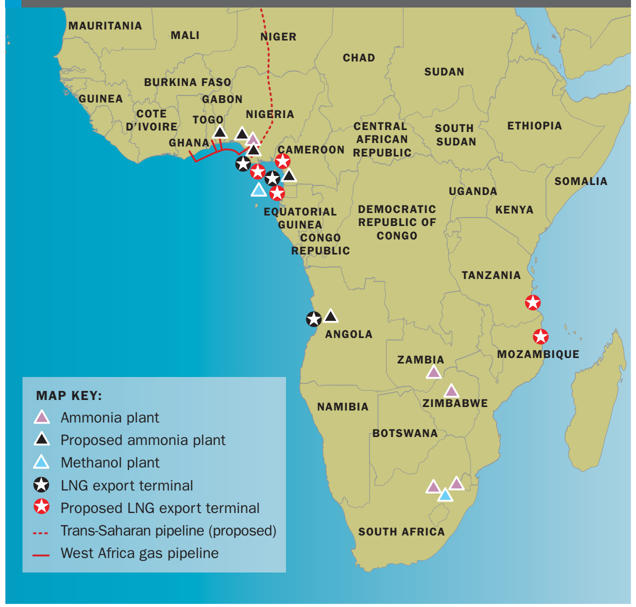
Zambia likewise developed coal-based capacity, and including 100,000 t/a of ammonia production at Kafue, operated by Nitrogen Chemicals of Zambia (NCZ), as well as downstream nitric acid, ammonium nitrate and ammonium sulphate production. Most of this capacity has been closed down, but the AN plant was re-started in 2013 using ammonia imported from South Africa, and there are plans to revamp the ammonia plant.

Zimbabwe operated an electrolysis-based ammonia plant at Kwekwe using electricity from the Kariba Dam, but this closed in 2012 due to the high costs involved. Again ammonia is imported from South Africa to operate the AN plant at the site, run by Sable Chemicals, but plans to convert the ammonia plant to coal gasification were suspended in early 2014.

Nigeria currently operates the only gas-based ammonia-urea capacity in sub-Saharan Africa, although again this has had its problems. Originally founded as the National Fertilizer Company of Nigeria (NAFCON) in 1987, with a Kellogg-designed ammonia plant with a design capacity of 330,000 t/a and a urea unit with 500,000 t/a of capacity, financial trouble led to lack of maintenance and production problems and NAFCON was wound up as a corporate entity in 2004. Private investment, via Egypt's OCI group, allowed the plant – now operated as Notore Chemical Industries – to start-up again after a revamp in 2010, and a debottleneck increased capacity to 430,000 t/a of ammonia and 750,000 t/a of urea in 2013. Now Notore has plans to add another ammonia-urea train, with 560,000 t/a of ammonia and 990,000 t/a of urea capacity, with front end engineering and design work completed by Mitsubishi Heavy Industries in 2013. EPC work was scheduled to be due for completion in 2016.

Outside of the nitrogen arena, the main success story has been the Atlantic Methanol (AMPCO) plant on Bioko Island, part of Equatorial Guinea, using associated natural gas from oil production. Commerical production began in April 2001, and after teething troubles were overcome and a revamp conducted capacity has increased from 850,000 t/a to 1.0 million t/a. However, attempts to develop gas to liquids (GTL) capacity in Nigeria by SasolChevron became mired in issues over contracting and gas allocation, with costs steadily rising, finally quadrupling to an estimated $10 billion over the 2000s and 2010s. The plant finally produced its first liquids in August 2014, 10 years behind the original schedule, and full production of 33,000 bbl/d is not anticipated until mid-2015.

Fig 1: Africa's gas and downstream industries



New projects

As well as the Notore expansion, there have been several other projects proposed for Nigeria. The furthest advanced is the Indorama Eleme Fertilizer and Chemicals Ltd facility, currently under construction at a brownfield site at Port Harcourt, River State. Toyo Engineering and Daweoo Nigeria are contractors, with KBR supplying ammonia technology for the 2,300 t/d ammonia plant. The Toyo urea unit will have a capacity of 4,000 t/d. The plant is currently projecting an on-stream date of 2016.

However, there have also been a plethora of projects which do not seem to have made much headway. A proposal by the Nigerian-based Dangote Group, owned by Africa's richest man Aliko Dangote, for an ammonia-urea complex at Agenebode in Edo State has completed front end engineering and design (FEED) work (conducted by Saipem) for the twin 2,200 t/d ammonia and 3,850 t/d urea plants, but so far there is no sign of any further work. India's Nagarjuna Chemicals says that it will likewise build 2.6 million t/a of ammonia-urea capacity at a new $16 billion'gas city' which the Nigerian government is trying to develop at Ogidigben in Delta State, across the river from the Escravos GTL plant, to include gas processing, power generation, and polyethylene and polypropylene capacity. So far, however, only site clearing work has been conducted.

Quantum Petrochemical says that it will build a $1.5 billion petrochemical complex at Ibeno, including polyethylene, polypropylene and methanol. Ground has been broken at the site, but again the progress of the investment is hard to judge.

Rather more detail has come from Brass Fertilizer Company Ltd, which announced in June 2014 that it is developing a $3.5 billion urea, methanol and gas processing plant on Brass Island in Nigeria's Bayelsa State. Shell will supply gas from its OML 33 field, and the site will process 500 million scf/day of sales gas, as well as building 1.27 million t/a of ammonia-urea and 1.7 million t/a of methanol capacity. Project management consulting is being conducted by Engineers India Limited (EIL), and finance is coming from a Scandinavian consortium led by Haldor Topsoe AS, and including DSV Group, IFU, Maj Invest and SwedFund, as well as South Africa's Consolidated Infrastructure

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Table 2: Assumptions for urea project in East Africa

Capacity	600,000 t/a
On-stream factor	90%
Gas consumption	17.1 bcf/year 32.7 MMBtu/tonne
Capital cost	$720 million
Capex	$1,200/tonne installed capacity/year
Operation & Maint	$22.8 million/year = $38/t/year
Construction time	3 years

Source: DNV KEMA

Group Ltd, and the local Bayelsa State Government. The complex is currently targeting start-up in 2019.

Elsewhere in the region, progress has been incremental on a proposed ammonia-urea plant in Cameroon, where German engineering giant Ferrostaal is developing a nitrogen complex with a projected capacity of 600,000 t/a of ammonia and 700,000 t/a of urea at the coastal port of Limbe. Ferrostaal's partners in the project include Cameroon's Societe National des Hydrocarbures, German engineering firm Proman, which holds the EPC contract, and trading company Helm, who will sell the plant's output. Helm, Proman and Ferrostaal are the main partners in Methanol Holdings Trinidad Ltd (MHTL). A gas supply deal was signed last year with Bowleven, but many hurdles remain to be overcome. In Angola, a consortium of Japanese firms including MHI, Toyo Engineering, Sojitz and Sumitomo has performed design and engineering work on an ammonia and urea plant which could be constructed next to the LNG unit at Soyo, with a capacity of 2,000 t/d of ammonia and 1,750 t/d of urea, but so far the project does not appear to have progressed any further.

And the difficulties of developing projects in Africa has also been illustrated by some of the projects which have failed to get off the ground. India and Ghana signed a memorandum of understanding to set up a 1.2 million t/a ammonia-urea plant in western Ghana, to be operated by Rashtriya Chemicals & Fertilisers (RCF), but the Ghanaians' inability to guarantee gas supplies led to the project foundering in mid-2014. Earlier in the year, Indian firm Tata Chemicals Ltd walked away from the Gabon Fertilizer Company development with the government of Gabon and Singapore-based agribusiness Olam International, which had been aiming to build a 1.3 million t/a ammonia-urea plant at Port Gentil, and partner Olam says it is trying to reduce its 62% shareholding.

Finally, more speculatively, Yara has been rumoured to be interested in developing an ammonia-urea project in Africa, once gas projects have come on-stream, but for the moment it appears to be biding its time. Tanzania, Angola, Ghana and Nigeria have all been tagged as potential sites for investment according to press reports. Pakistan's Fatima Group has likewise been tagged as a potential investor in Mozambique, with plans for an ammonia-urea plant running of cheap African gas for export to Pakistan.

There have also been several methanol plant project proposals for Mozambique, generally of the several hundred thousand tonnes per annum capacity, but methanol entrepreneur' Deo Van Wijk's GigaMethanol BV has suggested Mozambique as the location for its planned 7 million t/a methanol and methanol to gasoline plant.

Table 3: Nitrogen consumption in sub-Saharan Africa, 2012
x1,000 tonnes N

Country	Consumption
Cameroon	23
Cote d'Ivoire	81
Ethiopia	186
Kenya	108
Nigeria	560
Senegal	73
South Africa	425
Sudan	83
Tanzania	85
Zambia	21
Zimbabwe	41
Others	264

Source: IFA

Project costs

The economics of these projects are based around relatively cheap gas, but how cheap is cheap? DNV KEMA recently conducted a study on the costs of developing urea capacity in East Africa. Table 2 shows the assumptions made for the project. The key factor is the price achievable for urea; the study took a projected maximum f.o.b. price of $570/t and minimum of $250/t, with an average value of $400/t. At these prices, a gas price of $5.90/MMBtu was acceptable at the high end of the urea market, and a gas price of $1.80/MMBtu allowable at the average point, but at the low end of the market, the gas price netback would be -$2.30/MMBtu – a significant loss. Urea prices have ranged from about $250-500/t f.o.b. Yuzhnyy over the past 5 years, but over the past few months have been in the $300-350/t range. With oil prices falling and fertilizer markets likely to follow suit, the economics of an export-oriented project in Africa start to look quite shaky, especially when you begin to factor in not only the cost of developing infrastructure on a greenfield site, but things such as port availability, and intangible factors like political risk, corruption and bureaucracy.

Prices achievable for urea within Africa are often much higher, however, if sufficient domestic demand existed, and this would make the economics of a plant there much more reasonable. Here, though, the factor is lack of domestic demand. Outside of South Africa, southern Africa has lagged the rest of the world in terms of fertilizer application and agricultural productivity. Average fertilizer application rates across the region are just 8kg nutrient/ha, compared to a global average of 93kg and 100-200kg/ha in India and China. Soil fertility and yields are declining, with the situation exacerbated by periods of drought, political crises, war and economic stagnation. Table 3 shows local nitrogen consumption. Outside of Nigeria and South Africa, which both already have domestic nitrogen capacity, there is no single market capable of supporting a large scale urea plant, although the combination of Kenya, Tanzania, Ethiopia and Sudan could support an East African plant between them, and of course the presence of a plant could help stimulate local demand.

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Services to improve steam reformer performance

Johnson Matthey offers a number of different and equally powerful techniques to monitor reformer operation and resolve reformer problems. By focussing on solving specific issues and tailoring the offer to the needs of the operator, Johnson Matthey has a tool for assessing every reformer problem.

Many customers consider the steam reformer (reformer) to be the most complex and expensive part of their ammonia, methanol or hydrogen plant. Monitoring the plant during both normal and unfamiliar operations is therefore extremely important. In extreme cases, getting it wrong can lead to complete reformer tube failure. Whilst these cases tend to be the result of deviation from procedure, operation under normal conditions can also be far from optimum, having an impact on plant efficiency and reliability. Any time and money spent on monitoring a reformer is therefore a worthwhile investment; a well operated reformer is key to ensuring that a synthesis gas plant remains efficient, produces the maximum potential product and operates reliably with minimal downtime. Furthermore, optimised reformer operation reduces emissions per unit of product and is potentially safer.

Reformers suffer from a range of potential issues which can all lead to limitations on achievable production rates, reformer/plant efficiency and can lead to significant down time determining the root cause and making repairs. Problems on the reformer can be due to:

- catalyst poisoning due to incorrect operation of the purification section of the plant leading to excessive carbon formation and hence high tube wall temperatures (TWTs);
- tube failure due to excessively high TWTs or operational upsets;
- poor design or maintenance of reformer burners which can lead to flue gas maldistribution causing high TWTs or ineffective reformer performance;
- poor maintenance allowing degradation of refractory which increases reformer heat losses;
- damage to the tunnels resulting in flue gas mal-distribution and hence TWT mal-distribution;
- reformer tubes and sub components corrosion or operation above design temperatures leading to premature failure;
- maldistribution of combustion air leading to TWT variations.

Plant operators have a variety of techniques available to allow continual monitoring of reformer performance including on-line temperature and pressure measurement instruments on both the process and radiant sections of the reformer. However, in order to achieve the best possible reformer performance, monitoring should go well beyond this to a regular examination of the reformer TWTs. The most basic way to monitor TWTs is to use an optical (infrared) pyrometer on a regular basis to provide an indication on how well the reformer TWTs are balanced.

Reformer surveys

Johnson Matthey goes beyond straightforward TWT measurement and incorporates temperature correction and process engineering simulations to characterise a reformer performance, benchmarking against similar reformers and troubleshooting operational problems. This type of survey allows the operations team to make changes to the reformer balancing to improve reformer performance, often delivering significant value to the customer and improved plant production and efficiency.

Reformer surveys consist of an on-site visit from one or more experienced engineers, allowing them to accurately assess the reformer performance. First, the engineer conducts a visual inspection of the reformer to highlight any issues associated with, or damage that has occurred to the reformer tubes, refractory, burners and tunnels. The engineer then conducts the measurement of TWTs (Fig. 1). By using a proprietary calculation methodology, Johnson Matthey is able to correct the measured TWTs to account for the effect of background radiation from refractory and flue gas.

Fig 1: Measuring tube wall temperatures with Reformer Imager

Fig 2: Three dimensional model of corrected reformer TWTs

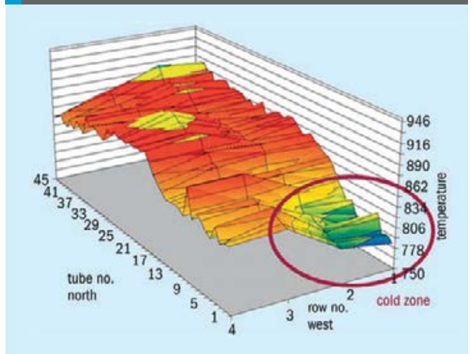
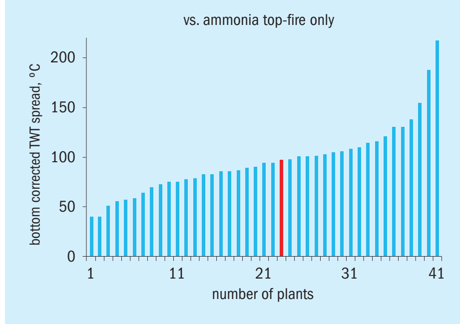


Fig 3: Benchmark example of an ammonia top fired reformer comparison of TWT spread



Plant data is simultaneously collected including flow rates, temperatures, compositions and pressures and this data is then reconciled using Johnson Matthey's in house process simulation tools[1,2] to eliminate any measurement inaccuracies. The reconciled data is then used in a process simulation to compare calculated TWTs against those measured and to provide a detailed assessment including pressure drop, carbon formation potential, approach to design temperature, fuel requirements and flue gas conditions. All of which are useful in determining the root cause of reformer problems.

The measured and corrected TWTs are statistically and graphically analysed to highlight any hot and cold zones or rows within the reformer and are compared against the visual inspection findings. For example, in Fig. 2, the reformer has a cold zone shown in the graph which corresponded to an area where the burner valves were partly closed in one part of the reformer.

Finally, the performance of the reformer is compared against similar reformers to benchmark the reformer operation (Fig. 3). This is done using the data from the huge number of reformer surveys conducted by Johnson Matthey. The database includes a large number of different data items, including reformer type, catalyst age, feed and fuel types, TWT measurement techniques, TWT measurements and TWT spreads.

TWT measurement techniques

Accurate measurement of TWTs is vital and TWT history may allow operators to estimate remaining tube life. Inaccurate readings could seriously impact plant operation e.g, high readings may lead to an artificial limitation of plant rate to stay inside design limits while lower readings compared to actual may mean that the tube life will be shorter than expected.

Johnson Matthey can employ a range of TWT measurement techniques as part of a reformer survey.

Table 1 gives a summary of how each reformer measurement device works. The requirement for background radiation correction with some techniques is not an issue as Johnson Matthey uses proprietary programs for this.

Optical pyrometer

Optical pyrometers have been used and proven over the decades and provide good results when background radiation is accounted for.

Optical pyrometer reformer survey

In this case study, a customer asked Johnson Matthey for a reformer survey at the start of life for a new catalyst charge. As no specific issues had been identified an optical pyrometer was selected as the tool to complete the TWT measurement.

As can be seen in Fig. 4, there is significant TWT spread across the reformer, with cold areas on both sides of the reformer. Investigation in the penthouse of the reformer found that the flow of fuel gas and combustion air to the burners was restricted in these areas and were therefore being fed less fuel and air. Discussion with the operator showed that this was due to the burners being over specified during the original plant design.

A detailed reformer balancing procedure was provided to the operator and this was implemented. The overall TWT spread was reduced to around 50°C, offering a significant improvement in operation which led to the ability to increase firing on the reformer, reducing methane slip and increasing production through efficiency delivering significant value to the customer.

Gold cup contact thermocouple

The gold cup contact thermocouple is a direct contact pyrometer which eliminates background radiation so is the ultimate tool when very accurate TWTs are required.

Gold cup contact thermocouple reformer survey

In the next example, the customer had identified using their own optical pyrometer

Table 1: Comparison of different TWT measurement techniques

Tool	Tube wall temperature measurement	Background correction required?
Optical pyrometer	yes – single point	yes
Gold cup contact thermocouple	yes – single point	no
Reformer Imager	yes – whole surface	yes

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Fig 4: **Corrected TWT results illustrating temperature spread**

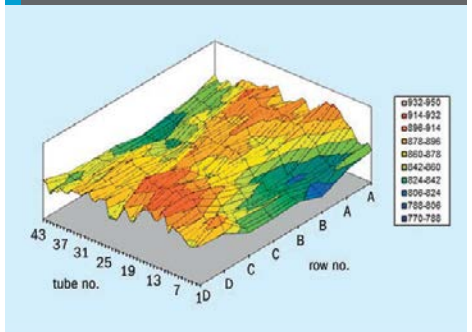

Fig 5: **Measuring TWTs with a gold cup**

that they may be running with hot tubes and they were concerned that this could cause a major reliability issue as these hot tubes could fail prematurely.

The gold cup contact thermocouple was selected by Johnson Matthey and the combination of the TWT measurement results with process simulations allowed Johnson Matthey to accurately model the temperatures and correlate this with plant data. The survey (Fig. 5) found that the maximum TWT was not being exceeded. Coupled with the fact that the overall reformer temperature spread was low, Johnson Matthey were able to give the operator confidence that they were operating as efficiently as possible within the parameters of their plant, and would not be causing unnecessary damage to the reformer tubes.

Reformer Imager

The Reformer Imager is the newest addition to the range of reformer survey tools from Johnson Matthey. The Reformer Imager operates at a suitable wavelength for the reformer radiant section and takes video images of the inside of the reformer. This new technique captures very high resolution images coupled with a wide viewing angle therefore temperature readings are available for every pixel in the image as well as being able to see part of the tubes that cannot be seen by the naked eye, e.g. the tops and bottoms of the tubes. The videos are recorded directly to a laptop and can be taken away for further analysis and can be used as reference to compare reformer performance over a given time period. In the comfort of the office, the software can be

Fig 6: **Example of data captured by the Johnson Matthey Reformer Imager**

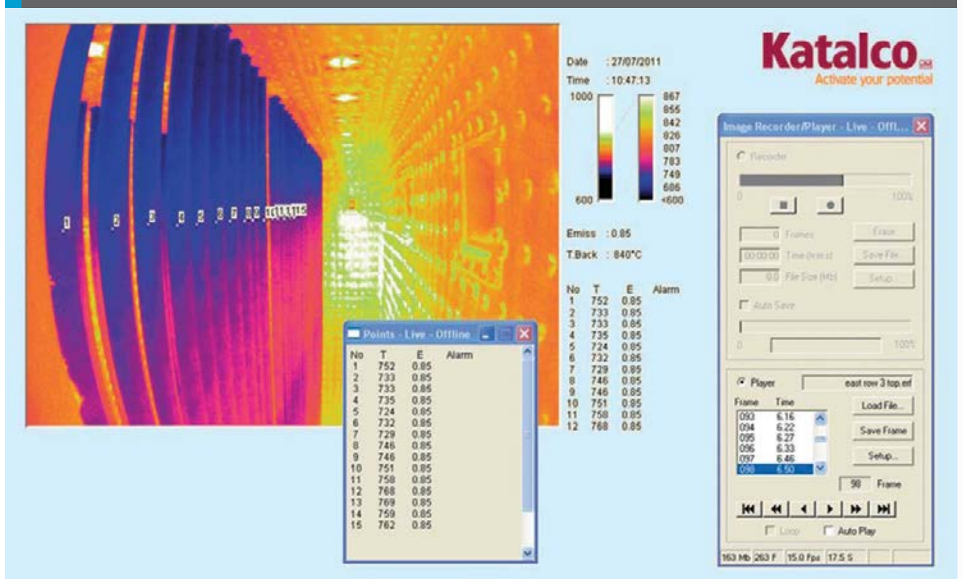

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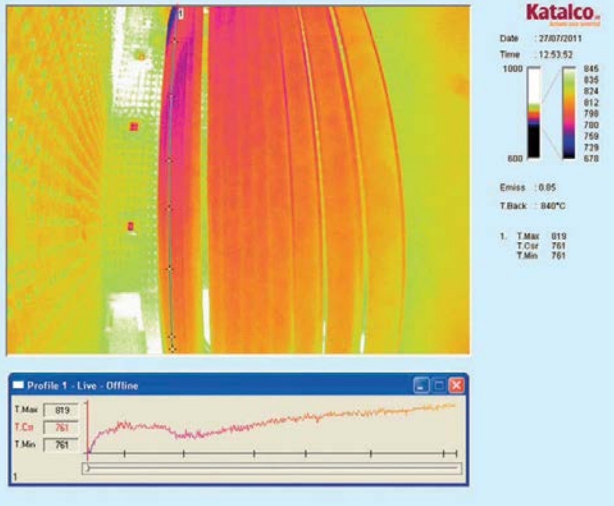
Fig 7: **Hot zone visible towards the top of the tubes**



manipulated to see problems before they can be seen with the naked eye, e.g. hot spots starting to form. These are unique advantages over any other temperature measurement technique.

Figure 6 shows the output from the Reformer Imager. The points on the tubes have been selected by the engineer to review the temperatures.

Reformer Imager reformer survey

A customer had identified hot areas on the top section of their reformer tubes when operating with a light feedstock. The catalyst loading in the plant had been selected to allow for flexible feeds, ranging from natural gas through to naphtha. As naphtha had not been used on the reformer for some time and was not expected to be used again, the customer was unsure as to the cause of the hot bands. The customer therefore requested assistance from Johnson Matthey in identifying what the problem could be.

At the time of the survey, the reformer was operating at significantly lower rates than normal. The TWT spread in the reformer was also very low, approximately 30°C at the bottom of the reformer, which is very good. To the naked eye, there was no evidence of the hot banding or hot areas reported by the customer in the top part of the reformer. However, as can be seen in Fig. 7, the Reformer Imager was able to identify a hotter zone in the top section of the tube. The normal temperature profile expected in this design of reformer is seen in the bottom two-thirds of the profile.

Using the Reformer Imager allowed insight into the profile temperature along the whole length of the tubes, and demonstrated that the temperatures in these hotter areas were still lower than the temperatures seen further down the tubes, and well within the design conditions for the tubes. Detailed process modelling of the reformer then indicated that, for the gas composition being fed to the reformer, the operating conditions, and the catalyst installed, the profile was exactly as expected.

The cause of these hotter areas and the unusual temperature profile through the tubes was due to the requirement of feed flexibility for much heavier feeds and the catalyst installed in the top of the tubes. The combination of the TWT measurement technique, together with Johnson Matthey proprietary modelling, determined that there would be no issues operating in this manner for the campaign, despite the slightly unusual profile observed. Not only that, additional modelling by Johnson Matthey at higher plant rates and as the catalyst aged determined that no issues would be expected and the catalyst should complete its design life without any operational incidents.

Reformer analysis and solution development

Where Johnson Matthey is approached by customers with specific problems, a quick diagnosis of the problem is made and the relevant equipment taken to site for the survey. In this case, a large top-fired reformer was suffering with severe localised hot spots. The plant was using catalyst from a Johnson Matthey competitor and only achieving short catalyst lives. The plant had also suffered hot spots in similar areas early in life of the new charge of competitive catalyst, and the hot spots had resulted in a burst tube.

Johnson Matthey completed a full diagnostic survey and identified a key issue for the plant: operating with a very tight carbon margin (rich feed), such that transients or upsets were likely to take it into the carbon formation operating zone.

The reformer imager was used as part of the Johnson Matthey diagnostics survey. As shown in Fig. 8, the ability of reformer imager to 'see round corners' allowed the on-site Johnson Matthey engineers to measure higher points up the tube than was possible with the optical pyrometer. The competitive catalyst installed did not have the carbon prevention ability needed to cope with the duty, and locations were identified where tubes were operating above the design temperature even though the plant operators had been strenuously managing the reformer burners to reduce hot areas.

The detailed reformer model arising from survey allowed Johnson Matthey to provide a tailored solution to resolve the issue. This consisted of an ultra-high activity catalyst in the top section of the tube and a larger catalyst for the bottom section of the tube, reducing overall pressure drop.

Fig 8: **View from the peep hole: unable to see tubes at the roof. Imager allows viewing of the tubes at the top.**

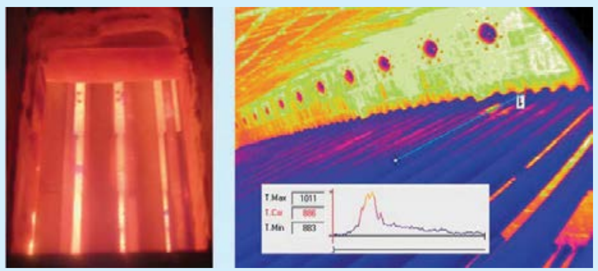


Fig 9: **Optimising loading solution from reformer analysis**

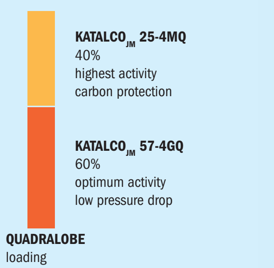
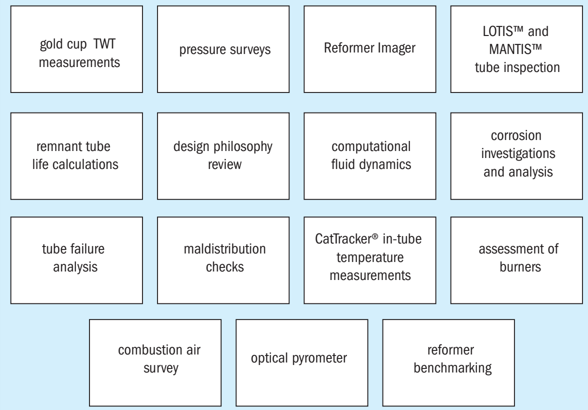


Fig 10: **Reformer monitoring techniques available from Johnson Matthey and partners**



Other reformer monitoring techniques

In addition to TWT measurement, Johnson Matthey and its partners can offer a range of reformer monitoring techniques[3] (Fig. 10). The combination of techniques selected for an individual customer is tailored to the specific problems faced by the plant operator to enable a targeted and comprehensive analysis of the issues.

As part of an extended reformer survey, additional process simulations can include both the reformer and the convection section to reconcile the heat and mass balance over both areas. The results of the process simulation are used to cross check plant measurements which can highlight plant measurement and operational issues.

Johnson Matthey has access to a range of simulation tools such as computational fluid dynamics for detailed fluid flow simulation of reformers and associated equipment items. The results of these simulations can be used to determine the performance of equipment on the plant and highlight the effects of potential modifications.

The CatTracker® catalyst temperature tracking system, available exclusively from Johnson Matthey, is now used as a process gas temperature measurement in reformer tubes providing customers with a unique insight into the process conditions inside the tubes of their reformer. Each CatTracker® probe is inserted into the centre of a reformer tube using a Johnson Matthey patented loading technique.

The CatTracker® requires no external sheath, and is approximately 6 mm in diameter and it is this combination of small diameter and Johnson Matthey loading technique that ensures there is no impact on catalyst loading and therefore reformer operation. The sensors give temperature readings at 11 different points in the reformer tube; the location of these sensors is determined by Johnson Matthey using proprietary modelling program, indicating the best heights for a given reformer.

There are many potential benefits including:

- Continuous on-line monitoring of the tube temperature profile, with the profile available in real time through the plant DCS system.
- Installation of alarms and trips based on reformer process gas temperatures, preventing costly reformer damage during transients.
- Determination of the tube temperature profile leads to more accurate prediction of operating proximity to the carbon formation zone, and hence the ability to avoid catalyst steam-outs as a result of carbon formation.

For those operators who want to know which reformer tubes will need replacement, LOTIS® and MANTIS™ tube inspection techniques can be employed to determine the amount of creep that a reformer tube has suffered during operation and hence give an indication of which tubes to replace. This service is provided through Johnson Matthey's partner Quest Integrity who has developed LifeQuest™ Reformer which uses the creep measurements and process data to determine the remnant life of the reformer tubes. This powerful technique allows the operator to determine which tubes need replacement at future plant turnarounds. (LOTIS®, MANTIS™ and LifeQuest™ Reformer are trademarks of Quest Integrity Group.) ■

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1. Cotton W.J., Davies M. and Fisher B.: "Advanced modelling tools and techniques for primary reformers"; AIChE ammonia plant safety symposium (Sep 2004).
2. Cotton W.J. and Foster C.: "REFORM – The World's Leading Reformer Simulation Program", Johnson Matthey Catalysts (2003).
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Faster and more reliable ammonia leak detection

Early detection of ammonia leaks in ammonia and urea plants reduces the incidence of explosion, fires and the exposure of humans to dangerous levels of gaseous ammonia. New improved methods of leak detection have been adopted in recent years including Boreal Laser's GasFinder technology and Smartec's fibre optic distributed temperature sensing.

Ammonia risks and incidents

Annual production of ammonia from over 550 plants worldwide now exceeds 200 million tonnes. The primary use (83%) of ammonia is for fertilizers – with the largest component being feedstock for urea manufacture (500 urea plants worldwide). Ammonia is stable in typical atmospheric conditions and is considered a non-flammable gas. However, ammonia is toxic and can produce negative health effects in humans. OSHA has set a 15-minute exposure limit for gaseous ammonia of 35 ppm by volume in ambient air and an 8-hour exposure limit of 25 ppm by volume. NIOSH recently reduced the IDLH for ammonia from 500 to 300. IDLH (Immediately Dangerous to Life and Health) is the level to which a healthy worker can be exposed for 30 minutes without suffering irreversible health effects. Exposure to very high concentrations of gaseous ammonia can result in lung damage and death. The average odour threshold of 5 ppm provides some warning of imminent danger. Given the large amounts of ammonia that are produced, transported and consumed worldwide, the potential for accidents is considerable.

Potential sources of ammonia leaks in ammonia and urea production are mainly associated with high pressure equipment, storage facilities and loading and unloading operations. The final step in the Haber-Bosch ammonia manufacturing process involves a high pressure ammonia compressor, having a set of primary and secondary seals. There is always ambient ammonia in the vicinity of this compressor because of bleed past the seals. Reliable ammonia monitoring around compressors is therefore desirable to ensure fast response in the case of primary seal failure.

Ammonia is stored in either high pressure spheres or cooled to below -33°C and stored in large tanks. The refrigeration compressor which recirculates NH_3 coolant represents another potential leak source. Ammonia is transported by trucks, railcars or ships to a distribution network of ammonia terminals. There are hundreds of such terminals worldwide. Storage facilities and trans-shipment at terminals provide multiple opportunities for accidental releases of ammonia.

Ammonia is the primary feedstock in urea production, so urea plants also have several continuous and discontinuous ammonia emission sources. A high pressure ammonia pump at the base of the urea tower is a key area of concern for leaks. Piping, valves and safety rupture disks represent other high risk leak sources. Liquid urea is turned into solid form in either granulators or prilling towers which typically produce substantial amounts of urea dust and ammonia off gas.

The potential for ammonia exposure in urea plants is probably underestimated. Many sections in a urea plant contain ammonium carbamate at high pressure and high temperatures. When a leak occurs, ammonium carbamate liquid will flash to atmospheric pressure and ammonium carbamate will dissociate into ammonia and carbon dioxide releasing significant amounts of ammonia vapours.

UreaKnowHow.com's urea incident database currently describes more than 30 incidents in urea plants and ammonia pipelines of which 80% are related to failures in high pressure equipment and high pressure piping systems. These incidents led to at least 40 fatalities and 80 additional injuries.

In all cases, early detection of ammonia leaks is vital to give operators precious time to reach personal protection equipment, to limit the area where ammonia vapours can cause problems and to shut off combustion sources. Improved ammonia leak detection will lead to a safer industry with fewer casualties and injuries.

Limitations of traditional ammonia detection

Traditional ammonia sensors are point sensing devices that use electrochemical, catalytic or semiconductor technology to measure ammonia concentration at a single point. These sensors are relatively inexpensive, but suffer from cross interference from other gases so can give false alarms. Cold and damp weather limits their performance and lifetime and they are poisoned by long term exposure to background levels of ammonia. Hence they can fail without notification and miss leak events. Sensor heads must be replaced periodically and challenged with test gas regularly

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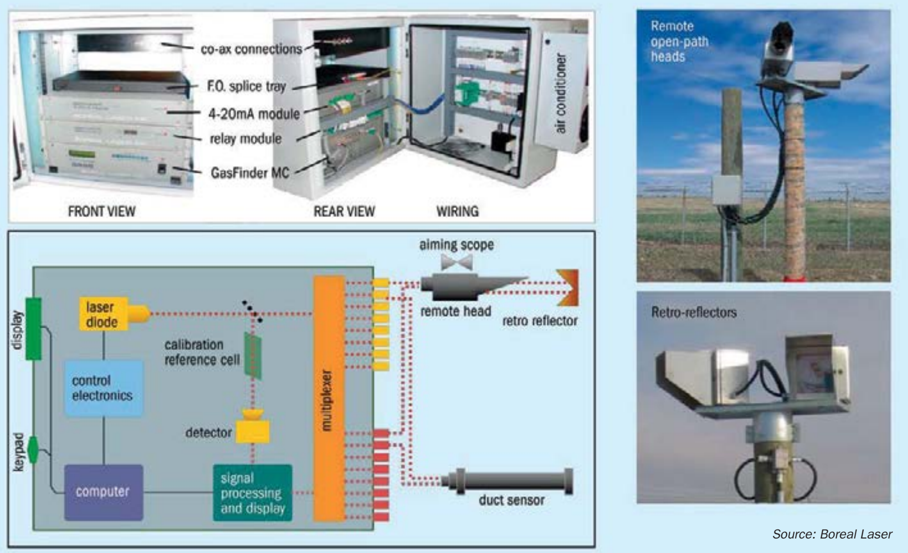
Fig 1: **GasFinderMC system for fixed leak detection**



Source: Boreal Laser

to ensure reliable operation. One client with an array of 30 electrochemical point sensors in a cool, damp northern latitude installation estimated spending $100,000 in maintenance costs per annum plus 1-2 man hours per sensor per month (total 50 man hours). Even in a well-maintained installation, typical T50 (time to 50% of full response) ratings are 25 seconds, so these sensors are slow to respond meaning that critical time can be lost in raising the alarm and responding to significant, dangerous ammonia release events.

For example, ambient levels of ammonia in the vicinity of compressors are typically between 18 – 25 ppm which will poison electro-chemical sensors rendering them ineffective in the case of a primary seal failure.

Laser gas detection

The laser gas detection method has several advantages over existing gas detection techniques. For practical purposes, lasers generate light at a single wavelength. Room temperature tunable diode lasers (TDL) emit light in the near infrared (NIR). Many dangerous gases absorb light in the NIR. Each gas has a unique absorption signature, or spectrum, made up of a large number of individual absorption lines. A TDL can be tuned to select a single absorption line of a target gas, which does not overlap with absorption lines from any other gases. Therefore, laser gas sensing is very selective, and does not suffer from interference from other gases. The single-wavelength nature of laser light also means that laser gas analysers obey the Beer-Lambert law and exhibit a linear response over a wide dynamic range.

TDLs generate only a few mW of power and are therefore eye-safe. However, all this power is concentrated at one wavelength, the wavelength where gas absorption occurs. So, high signal to noise ratios are achieved, and response times are short, typically about 1 or 2 seconds. Diode lasers provide all the advantages of other semiconductor devices. They are small, solid-state devices. They operate at room temperature and have long-term reliability (over 15 years).

Being an optical technique relying only on the absorption of light to indicate the presence and amount of a target gas, laser gas detection is ideally suited to open-path or line-of-sight (LOS) configurations. Boreal Laser of Canada is a leading manufacturer and innovator of open path laser based gas detectors. Working with many of the largest industrial users and best research organisations in the world Boreal's GasFinder technology has been proven in numerous safety, environmental and process control applications. Boreal products are robust, reliable and low maintenance and are often used in critical safety applications.

Figure 1 presents a schematic representation and photographs of a GasFinderMC system, a multiple channel laser gas detector that provides up to eight independent measurement paths. This configuration takes advantage of the fact that laser light from NIR TDLs can be easily coupled into inexpensive and highly transmitting optical fibres. The light from a single laser can then be switched into several fibres, enabling multiple point measurement with a single laser gas analyser. This leads to lower cost per measurement and easier installation in harsh and potentially explosive environments.

The central control unit is a 19" rack mount unit that contains the laser, multiplexing and data processing components. It also houses a stable gas reference cell in order to maintain laser wavelength line-lock and provide a reference signal. Fibre-optic cable carries the laser light to transceiver (transmit/receive) heads, which direct the beam along a path to a reflector. The return light is collected on

AMMONIA SAFETY

Fig 2: **GasFinder2 for portable safety and environmental monitoring**

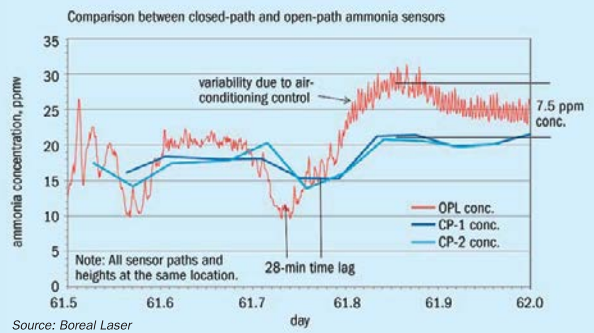
Source: Boreal Laser

photo-detector inside the transceiver head. The resulting photo current is returned to the central control unit on coaxial cable. A custom radio frequency barrier module is included in the coaxial cable return when paths are located in potentially explosive areas. The analyser system is available in open path, stack/duct, and process monitoring configurations.

Built-in self-diagnostics and full data communications capability ensure analyser up-times typically in excess of 99.9%. The absence of any moving parts, consumables or regular calibration requirements ensures low cost of ownership.

Figure 2 shows GasFinder2, a laser gas analyser using the same basic technology described above, that has been configured for portable use. This configuration consists of an integrated transmitter/receiver unit and a remote, passive retro-reflector array. The GasFinder2 is aligned with the retro-reflector using a two-axis instrument mount assisted by a telescopic sight and an on-board visible aiming laser. GasFinder2 can operate with path lengths from 1m to 1000 m, is battery operated and weighs less than 5kg. It takes less than 10 minutes to set up the instrument and commence measurements. Therefore GasFinder2 is ideally suited for portable use, and temporary installations. This portable instrument can also be adapted for multiple-path monitoring with a scanning mount or adapted to vehicle mounted mobile operation in a fibre coupled configuration (Adam et al, 2008).

Fig 3: **Hysteresis effect**



Source: Boreal Laser

Table 1: **Advantages of laser gas monitoring**

Open path laser	Traditional point sensors
Gas specific: no false alarms	Cross sensitive to other gases: false alarms possible
One second response: more time to react	Relatively slow to respond: typical T50 rating of 25 seconds
Optical absorption technique: no poisoning, no "memory" effects	Poisoned by exposure to NH_3: exhibits memory effects
Reliable unattended performance in all climate conditions	Some sensors only rated to -10°C: precludes outside winter work in many locations
No consumables, no moving parts: minimal maintenance, reduction in operating and maintenance needs	Maintenance intensive: require calibration, test gas, replacement heads. Large operating and maintenance cost
Area coverage rather than individual points: more reliable leak detection	
Laser light not absorbed by water vapour: enables long paths – 500 m or greater	

Open path laser gas measurements yield well to analysis by various flux calculation models. GasFinder data can be combined with meteorological data such as turbulence, atmospheric stability and wind speed, and then analysed by one of several commercially available stochastic or deterministic dispersion models to calculate the magnitude and direction of gas plumes escaping manufacturing plants. For example, GasFinder data output is compatible with SAFER Systems SAFER Real-Time® plant-wide emergency response solution enabling more accurate predictions of the off-site fate of gas plumes resulting from in-plant leaks.

Laser based ammonia detectors typically operate at a wavelength near 1.5 microns, where well resolved ammonia absorption lines can be found. Boreal Laser has thus developed state of the art ammonia detectors, which are specific to ammonia (no interference with other gases) and which are able to detect gases over a large area and not just single points.

Laser benefits for ammonia leak detection

In recent years, the fertilizer industry has come to appreciate the benefits of laser technology for detecting leaks and monitoring ambient concentrations of ammonia and hydrogen fluoride. Reliable detection of these gases has proven to be especially tricky for traditional electro-chemical gas detectors, with cell saturation, large hysteresis effects and calibration drift being common challenges. Detection solutions which require the air sample to be pumped from an intake site to the sensor are susceptible to NH_3 losses in sample

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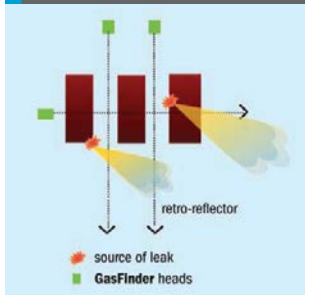
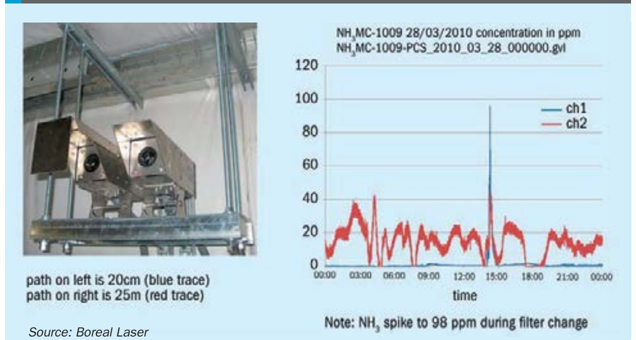
Fig 4: **Typical open path detection configuration for compressor building**



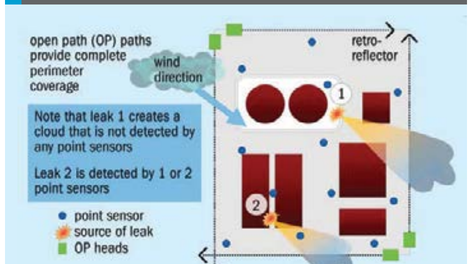
Source: Boreal Laser

Fig 5: **NH_3 compressor room monitoring**



Source: Boreal Laser

Fig 6: **Typical multiple path open path leak detection installation**



Source: Boreal Laser

Fig 7: **Periphery detection at ammonia storage area (left) and plant boundary (right)**

PHOTOS: BOREAL LASER

tubes and plugging of such tubes – especially during release events. Conversely, laser-based open path monitoring of NH_3 and HF emissions is easy and reliable, with detection sensitivities that are ideally matched to typical alarm levels of 3 to 10 ppm for HF and 30 to 100 ppm for NH_3. The wide dynamic measurement range of the laser technique enables reliable detection of incipient leaks of both gases, with significant associated benefits. Firstly, potential leak situations can be identified and fixed before they become dangerous. Secondly, there is an economic benefit as costly product losses are limited. Figure 3 demonstrates the faster response and absence of hysteresis in open path laser measurements compared with traditional techniques. Table 1 summarises the benefits of open path laser detection compared with traditional gas detection techniques.

The unique features of Boreal's laser based ammonia detectors therefore make them ideally suited for monitoring ammonia emission sources, safeguarding ammonia compressors, pumps, storage vessels, high pressure equipment and monitoring for fugitive ammonia emissions along facility boundaries and fence-lines.

HP pumps and compressors

Figure 4 shows a schematic for open path gas detection for high pressure ammonia and carbamate pumps or an ammonia refrigeration compressor. Since laser gas detectors are not poisoned by the typically high ammonia background levels found around these pumps or in a compressor room they provide an ideal solution for safety monitoring in these areas.

In addition to providing a reliable early warning alarm, open path laser detectors can initiate mitigation procedures. Due to presence of process gas in compressor house equipment, as per API 2030, installing a water spray system is recommended. However thermal stresses will be produced by the spraying of water on hot surfaces. A better solution uses vertical water curtains. A perforated pipe is placed around the equipment on a 3-6 m height. Variations in the curtain can be made by using different nozzles at different locations. A low alarm generated by a laser ammonia detector sends a warning to the control room. A high alarm activates the water curtain.

Boreal Laser has installed several systems for monitoring ammonia releases in compressor environments. Figure 5 shows a typical installation and data from a compressor monitoring installation in Canada. During the initial design phase of an ammonia refrigeration control system, the customer required area monitoring for low ammonia concentrations in the engine room instead of traditional point sensors. This client also wanted to detect high concentrations for the purpose of shutting down possible sources of combustion. The Boreal Laser GasFinderMC was able to support both of these requirements.

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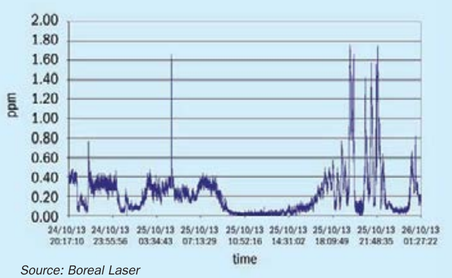
Fig 8: **Ammonia storage tank monitoring. Temporary monitoring with GasFinder2 on left. Permanent monitoring with GasFinderMC on right**

PHOTOS: BOREAL LASER

Fig 9: **Path averaged NH_3 concentration on a 320m path along a boundary near a cold ammonia storage tank and cold ammonia flare**



Source: Boreal Laser

A laser transceiver head was installed at one end of the building with a reflector at the other end (25m) to pick up small ammonia leaks in the 0-65 ppm range. A second, short path (20 cm), detector was mounted in the ceiling to detect high concentrations of ammonia in the 0-15,000 ppm range. The control system used 4-20 milliamp outputs from the Boreal equipment to generate alarms and shut down various equipment based on reported ammonia concentrations.

Periphery detection

Large ammonia/urea manufacturing facilities are often required by local regulators to guarantee that specified limits of ammonia are not exceeded at facility boundaries. This is especially so if there are nearby residential areas or public facilities such as schools, hospitals or shopping malls. In such cases, open path laser gas detection along the boundary or fence-line is the ideal solution.

Figure 6 shows a typical Boreal Laser configuration and Fig. 7 an example installation photograph for ammonia leak detection at process unit or facility boundaries. This figure demonstrates how open path detection provides more complete and reliable coverage than point sensors. One of Boreal's longest operating installations is one comprising two GasFinder2 instruments that have provided continuous, trouble-free ammonia monitoring over two 800 m fence-lines at a refinery in California since 1997.

Fig 10: **NH_3 monitoring at top of prilling tower with 2m open path measurement. Note persistent mist**

PHOTO: BOREAL LASER

Ammonia storage tanks and loading terminals

Ammonia storage tanks and loading terminals are high risk leak sources in any ammonia/urea complex. Several failure mechanisms like stress corrosion cracking of the carbon steel wall and atmospheric corrosion can influence storage tank integrity. Reliable ammonia leak detection is vital to ensure tank integrity and to increase the time between inspections. Regular making and breaking of piping connections in ship, rail and truck terminal creates multiple opportunities for leaks. Therefore, storage tanks and loading/unloading terminals are normally high on the list of priorities for implementing open path leak detection at ammonia/urea complexes. Figure 8 shows two typical storage tank monitoring installations, one for temporary monitoring with a portable GasFinder2 and the other a permanent GasFinderMC installation. Figure 9 shows typical fence-line ammonia data generated from the GasFinder2 temporary installation near an ammonia storage tank.

Stack emission measurement

A urea plant contains several locations where continuous and discontinuous ammonia emissions occur. These include absorbers, stacks and prilling towers. In a Saipem urea plant additional ammonia gas is sometimes added to the emission point from the medium pressure recirculation section to control its explosive character. A Boreal Laser open path ammonia detector is currently participating in a trial to monitor ammonia emissions from the top of a prilling tower in India (see Fig. 10).

HP equipment leak detection

In the event of a leak in the loose liner of high pressure urea equipment, three situations can be distinguished: carbamate gas leaks, carbamate liquid leaks of carbamate liquid with some urea leaks. In all three situations solidification can occur due to the expansion from synthesis pressure to atmospheric pressure and the accompanying reduction in temperature. When this happens, the leak detection lines can become clogged, especially when these lines are not heat traced and insulated. Active and accurate detection of ammonia is required in order to identify a leak at an early stage. Active means that one either flushes the leak detection system with an inert gas stream or one creates a vacuum pressure in the leak detection system.

Boreal proposes an improved leak detection system, which is also able to measure leak rates and detect false air intake, based on applying vacuum pressure to the leak detection holes (sometimes called weep holes). The Boreal Laser ammonia detector provides an immediate (one second) response in case of ammonia breakthrough in any of the weep holes. This system can be applied to all high pressure equipment items such as reactor, HP stripper, HP carbamate condenser, HP separator and HP scrubber. One multi-channel Boreal GasFinderMC detector can simultaneously monitor all these high pressure equipment items.

Fig 11: **Distributed temperature sensing cable and installation example on an ammonia pipeline**

PHOTO: SMARTEC

Fig 12: **Distributed temperature sensing interrogator**

Source: Smartec

Ammonia leaks in pipelines

Following recent developments, the use of distributed leakage detection systems based on optical fibre sensing now offers a solution for the early detection and localisation of small ammonia leakages on long pipelines. Using a limited number of very long sensors it is now possible to monitor the behaviour of pipelines with a high measurement speed at a reasonable cost.

Pipeline leakages may have different origins, such as corrosion, fatigue, material flaws, shocks, abnormal temperatures, extreme pressures, or excessive deformations caused by ground movement. In the case of liquefied or pressurised gases, leakages can be detected by the rapid drop of temperature due to the evaporation of the released liquid and its evaporation gases or due to gas expansion. These local thermal anomalies can be reliably detected by a fibre-optic distributed temperature sensing system (DTS) able to detect temperature changes of the order of 1°C, with 1 metre spatial resolution and 10 seconds response time. A fibre optic cable is installed all along the whole length of the pipeline and is connected to a measurement system that can automatically detect temperature anomalies which are tell tale of leakages and generate an alert to initiate appropriate response actions on the affected pipeline section. Such a system is deployed at several industrial sites including Yara France, and Borealis.

Smartec fibre optic distributed temperature sensing

Unlike electrical and point fibre optic sensors, distributed sensors offer the unique ability to measure temperature along their whole length. This capability allows the measurement of thousands of points using a single transducer. The most developed technology of distributed fibre optic sensors is based on Raman scattering. These systems make use of a nonlinear interaction between the light and the glass material of which the fibre is made. If light at a known wavelength is launched into a fibre, a very small amount of it is scattered back at every point along the fibre. Besides the original wavelength (called the Rayleigh component), the scattered light contains components at wavelengths that are different form the original signal (called the Raman and Brillouin components). These shifted components contain information on the local properties of the fibre; in particular the intensity of the Raman peak shows strong temperature dependence. When light pulses are used to interrogate the fibre, it becomes possible, using a technique similar to radar, to discriminate different points along the sensing fibre by the different time-of-flight of the scattered light. Combining the radar technique and the analysis of the returned light, one can to obtain the complete profile of temperature along the fibre. Typically it is possible to use a fibre with a length of up to 30 km and obtain temperature readings every 1 m. In this case we would talk of a distributed sensing system with a range of 30 km and a spatial resolution of 1 m.

Systems based on Raman scattering typically exhibit a temperature resolution of the order of 0.1°C with measurement scan times as low as 10 seconds.

Components

The typical components of a distributed temperature sensing system are the following:

- sensing cable to be installed along the pipeline (see Fig. 11);
- interrogator (see Fig. 12);
- multiplexer to allow multiple cables to be measured from one interrogator, or to provide interrogation of both ends of a cable for redundancy;
- data analysis software with automatic detection of leaks and system function validation (proof testing);
- relay module used to transfer alarm information to other plant systems (e.g. to initiate automated emergency shut-down sequence);
- user interface that shows the exact location of a leak (see Fig. 13).

Fig 13: **Example of user interface showing location of multiple events, e.g. leaks**

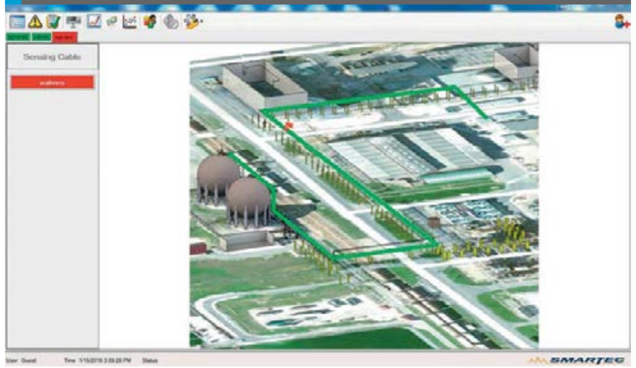


PHOTO: SMARTEC

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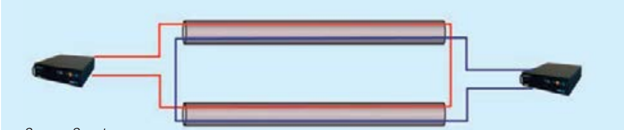
Fig 14: **Redundant setup with two interrogators and looped fibres**



Source: Smartec

Leak detection

In process safety, a small ammonia leak is a release of anhydrous ammonia that has effects outside the plant. To have consequences outside the plant the leak is typically of more than a few kg per second. On the other hand, in occupational safety, a small release is in the order of a few grams per second.

The basic principle of pipeline leak detection through the use of distributed fibre optic sensing relies on a simple concept – when a leak occurs at a specific location along the pipeline, the temperature distribution around the pipeline changes. This change in temperature is localised both in space (a few meters around the leak location) and in time (the onset of the leak). This makes the algorithmic detection of leaks relatively easy to implement. The origin of the temperature disturbance around the pipeline depends on the type of pipeline and its surroundings.

In the case of ammonia leaks from above-ground pipelines, the main effects are the following:

- The liquid component of the ammonia leak drops to a temperature of -33°C and wets the sensing cable directly through dripping, splashing and spraying, provoking a fall in the recorded temperature.
- The gaseous component of the ammonia leak forms a cold plume that also cools down the sensing cable.
- Part of the gaseous component of the ammonia leak condenses on the pipe and cable surface, producing an additional liquid phase.
- The leak also produces a drop in temperature of the pipeline itself that is transmitted to the sensing cable.

If the ambient temperature is close to -33°C, the evaporation of liquid ammonia is limited and the gas release will be small, detection will be more difficult, but in these cases the impact on the environment is reduced.

Knowing the above effects, one can determine the ideal sensing cable placement around the pipeline. The same system setup can be used for leak detection of buried ammonia pipelines, because a localised temperature drop is also expected in that scenario.

Reliability and availability

For mission-critical applications such as ammonia leak detection, several strategies can be used in order to ensure the reliability and high availability of such a system. Optical fibres are always installed inside a cable to protect them mechanically, while ensuring the minimum possible thermal isolation. Additional strategies for increasing reliability and availability include:

- Using a looped cable, where both ends of the sensing cable are connected to separate channels of the interrogator. In case of cable damage, it is possible to measure temperatures up to the damage point. If it is looped from both ends of the cable, the whole length of pipe can still be monitored in case of a single failure point.
- Using cables containing multiple optical fibres ensures that if a single fibre is damaged the others can still be used.
- Using multiple cables along the same pipeline.
- Using two interrogators connected to different fibres in the same cable or to different cables. In this case it is also possible to implement voting criteria among the interrogators to optimise availability and reliability and reduce false alarms (see Fig. 14).

Technology validation

Short- and long-term tests and experiments have been carried out to validate the technology for ammonia leak detection and for its compatibility with real-life fertilizer plant environments.

On-site

Several tests were performed on-site at the Yara plant in Le Havre, France. These tests consisted of pouring liquid ammonia on pipelines equipped with an optical fibre sensor and verifying the temperature drop measured by the system. Typically, 1 kg of ammonia was poured on a pipe section of 0.5 m over the duration of 1 min (see Fig. 15).

Figure 16 shows the temperature drop recorded by the measurement system at the leak location. Temperature drops of 5°C over 20 seconds and 10°C over one minute were recorded in all tests. This response can differentiate between the normal temperature change that occurs when the line is put into service for a product transfer in the following ways:

The rate of temperature change from the leak is higher than the one recorded during the initiation of ammonia transfer.

The operational changes, such as initiation of ammonia transfer, of temperature affect long sections of the pipeline uniformly, whereas the leaks only affect a small portion of the pipeline.

Tests were also performed on pipelines covered with ice, showed that the ammonia quickly melts the ice and comes into contact with the sensing cable (initially covered by ice itself).

Laboratory leak simulations

In a series of laboratory experiments carried out at the French INERIS laboratory (part of the French Ministry of Environment), the performance of the system was evaluated in the presence of a real leak from a pipeline. These tests were necessary to verify the field test results, i.e. that the necessary temperature drop would also be produced in real leak conditions.

The experiment consisted of a pipeline section including a cut with an equivalent section of 5%. The pipe contained anhydrous ammonia at 7 bars (100 psig) and the cut produced a leak of 38-45 g/s (5-6 lb/min) after opening the quick-release plug. High-speed and infrared cameras were used to capture the dynamics of the leak and the resulting temperature changes. Both vertical and lateral leaks were tested with the cable placed under the pipeline.

The experiment showed a very quick temperature drop of more than 10 °C/min that was easily detected by the system. The high-speed video images, showed no significant spray or dripping of ammonia on the cable, therefore the temperature drop was attributed mostly to the ammonia gas cloud and its re-condensation and evaporation on the pipe and on the sensing cable.

The two drops of temperature clearly visible in Fig. 17, taken approximately 20

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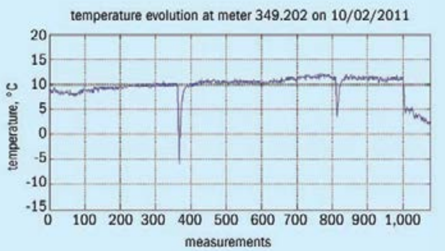
Fig 15: **Ammonia pouring test setup**

PHOTO: SMARTEC/YARA FRANCE

Fig 16: **Temperature drop recorded during two ammonia leak tests and a pipeline restart**

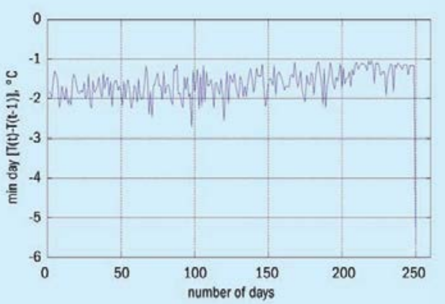


Source: Smartec/Yara France

Fig 17: **Plot of temperature as a function of distance during leak test**

PHOTO: SMARTEC/YARA FRANCE

Fig 18: **Maximum daily rate of change without leaks and with a leak test at the end**



Source: Smartec/Borealis

seconds after the release starts, are due to the loop configuration used for the sensing cable. The cable passes twice in the leak zone, on its way out and on its way back to the instrument.

Performance without leaks

To evaluate the temperature variations occurring during normal plant operations, without ammonia leaks, a sensing system was installed on a transfer pipeline used to refill trucks. This type of pipeline is subject to frequent and sudden temperature changes due to the start-and-stop nature of these operations. This scenario creates complex temperature patterns compared to the constant flow in a production transfer line.

A test period spanning both summer and winter seasons, collected data every 10s over 250 m of a pipeline. The data was analysed statistically and it was found that the maximum temperature variation between two measurements was 2.5°C well below the rapid changes observed in the case of a leak. It is therefore possible to operate such a system without triggering false alarms in normal operational conditions. Figure 18 shows the tests results, including a leak simulation test performed at the end of the test period that clearly exceeded the threshold.

Recommendations

The following recommendations are based on the knowledge accumulated during the laboratory and field tests. They serve as a starting point for the implementation of such an ammonia detection system in a plant.

Cable installation on different types of pipelines

The cable installation procedure aims at maximising the probability of detection. It is recommended to install the cable(s) in a way to increase the likelihood of contact with the leaking liquid ammonia and the resulting gas cloud:

- In the case of horizontal pipeline sections installing the cable at the bottom of the pipeline and attach it with ties to the pipe every 50 cm. The cable does not need to be in contact with the pipe along its whole length, since it will catch dripping liquid ammonia and the cold ammonia gas.
- For vertical sections install the cable in a spiral with a pitch of 1 m in order to catch any down flow of ammonia.

These recommendations are also valid for insulated pipelines, where the sensing cable can be installed outside the insulation cover in the same positions. Additional pipeline elements such as valves, splits and pumps require specific installation schemes.

Performance of data acquisition unit

Based on the test results and the experience gathered on several plants in France and Italy, the recommended minimum configuration (without redundancy) is as follows:

- 1 data acquisition system with 2 channels;
- measurement scan time of 10 s per channel;
- temperature resolution of 0.2°C for 10 s measurement scan time;
- spatial resolution of 1 m;
- cable configuration consisting of a single cable with 4 optical fibres, 2 fibres connected at the far end to form a loop connected to the two interrogator channels;
- automated trip testing system (ATTS).

The ideal configuration, which includes redundancy, is as follows:

- 2 data acquisition systems with 2 channels each;
- measurement scan time of 10 s per channel;
- temperature resolution of 0.2°C for 10 s measurement scan time;
- spatial resolution of 1 m;
- cable configuration consisting of two cables with 4 optical fibres each with the two cables connected at the far end to form a loop (each loop connected to the two channels on each interrogator);
- voting system;
- ATTS.

Reliability and confidence level

An ammonia leak detection system is likely to sit idle for all its life, hopefully never detecting any real leak. Idleness presents a challenge for reliability. The system will be "forgotten" most of the time, and it is difficult to guarantee that it will perform perfectly the day it is really needed. Ensuring and certifying a high confidence level becomes imperative in these conditions.

Since it is difficult to frequently carry out leak simulations on the line to verify the system response, Smartec has developed a device that can carry out such tests in a fully automated way. The automated trip testing system (ATTS) is a device, fully independent of the data acquisition system, which can create an artificial leak along the sensing cable. In so doing, the correct response of the system and alarms can be verified. The ATTS uses a Peltier cell to cool a 2 m section of optical fibre at a rate similar to the one observed in the case of ammonia leak. The system observes the signal coming from the relay module to verify alarm triggering. A dedicated relay is allocated to the ATTS fibre section, so that the alert in this zone does not trigger any pipeline shutdown sequence, is not transmitted to the operator, but is recorded in the plant event log. The ATTS is placed at the end of the fibre loop, so that the integrity of the whole fibre can be verified in one test. Typically, a leak simulation can be simulated every hour, so that thousands of tests are carried out every year.

If multiple redundant reading units are used, it becomes possible to increase both availability and system reliability by using a voting system on the relay outputs. A two out of two configuration is recommended, implementing a fall back to one out of one if one system is unavailable.

Detection algorithms and thresholds

The recommended initial settings for ammonia leak detection are:

- an absolute temperature threshold set at the average pipe temperature -20 °C;
- rate of change thresholds of -3 °C/10 s and -10°C/1 min.

It is suggested to carry out a test period including summer and winter to adjust the thresholds before using the system as part of an automated safety loop.

Annual testing

In addition to the regular tests carried out by the ATTS, it is good practice to carry out an annual test on the real line. This test should be done such that it verifies the whole system including detection, alarm chain functionality, and valve shutdown action. During this test, a valve bypass can be opened to ensure continuity of flow. The test can be carried out by pouring ammonia directly on the line, or using a CO_2 fire extinguisher. The point is to simulate a similar temperature drop to a real ammonia leak.

Future work

In future, Smartec plans to explore the use of the same technology to address leaks from buried ammonia pipelines. ■

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New insights into the ammonia oxidation process

A new tool for process simulation developed by amoxEXPERT provides unprecedented insight of the reactions occurring at the catalyst in the ammonia oxidation process, helping to understand and positively adjust the most important yield-determining step. **Dr J. Neumann** reports on these new developments and how they can be used to optimise the ammonia oxidation process.

The performance of the Ostwald process for NO synthesis from NH_3 and O_2 on a Pt alloy gauze catalyst has been simulated by applying a model which describes the formation of all nitrogen-containing products, N_2, NO and N_2O of which only nitric oxide (NO) is the target product of economic interest. The simulation is based on science-based rate equations obtained from well-defined surface experiments.

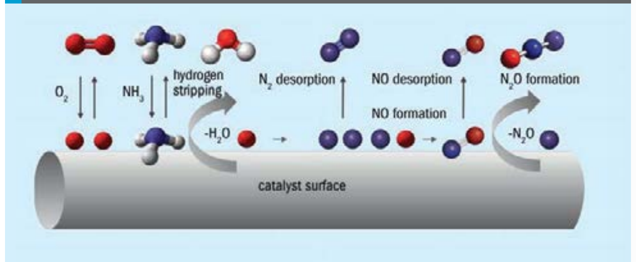
In consideration of thermodynamic principles and combined with appropriate mathematical models, the modelling allows the prediction of product selectivity for the reactions forming N_2, NO and N_2O under the conditions of an industrial ammonia burner.

Applying the individual product selectivity of each nitrogen-containing product in the process simulation allows the precise prediction of the NH_3 conversion rate, heat generation and temperature at each gauze layer in the catalyst pack. Input values needed for the mathematical iteration method only consist of the parameters temperature, pressure, flow rate and composition of the mixed gas.

When reversing this correlation, the process simulation consequentially allows for a systematic optimisation of operating conditions with the clear objective to increase the process efficiency toward NO.

In a subsequent step, the dynamic process simulation also takes into account time-varying conditions by the incorporation of heat and mass accumulation.

Fig 1: **Reaction steps of ammonia oxidation on the catalyst surface**



This allows optimisation of the start-up procedure as well as the investigation of extreme operating conditions, e.g. for the improvement of process safety.

Modelling

In view of the large number of chemical reactions and species formed on the catalyst surface, the full details of which are largely unknown, modelling reduces the complexity of the model compared to reality, by focusing on the essential determining factors, which are important for the process.

There are only a few reaction kinetics models which apply reliable surface examination. The most pragmatic modelling characterises the adsorption and desorption of reactants and products, the hydrogen stripping of ammonia and the formation of surface adsorbed NO (see Fig. 1).

The kinetic model describes the progress of the chemical reactions by differential equations. Here the three levels of the reaction network, the reaction-rate approaches and parameter estimation, must be solved in parallel via mathematical iterative method.

The results of kinetic modelling are the reaction rates and thus the selectivity of the nitrogen-containing products under the reaction conditions in correlation with the reaction temperature.

Figures 2 and 3 illustrate the relative formation rates for the three nitrogen-containing products N_2, NO and N_2O as well as the resulting process selectivity according to temperature. The modelled process data of a medium-pressure process are contrasted with the data of a high pressure process to illustrate the differences in formation rates and selectivity as a function of temperature.

Fig 2: **Correlation of temp. and N_2 / NO / N_2O formation**

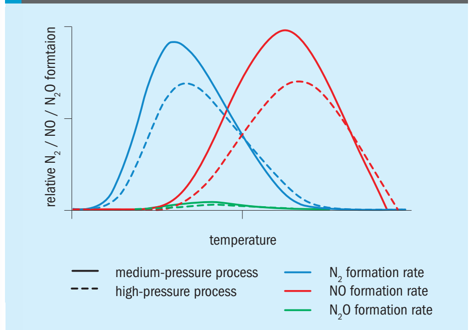


Fig 3: **Correlation of temp. and N_2 / NO / N_2O selectivity**

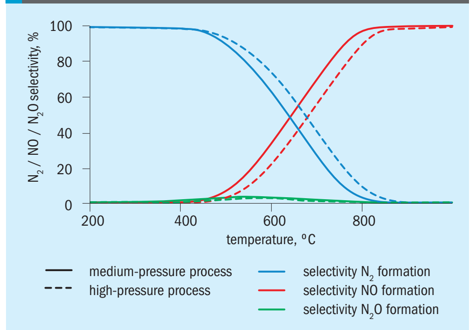


Fig 4: **Correlation of temperature and gauze layer**

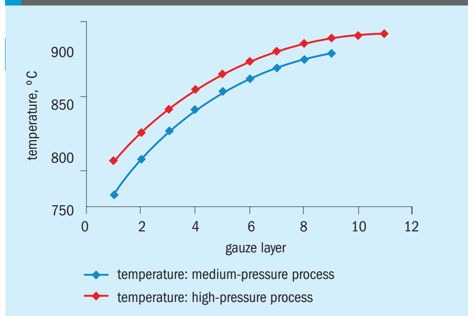


Fig 5: **Correlation of total NH_3 conversion and gauze layer**

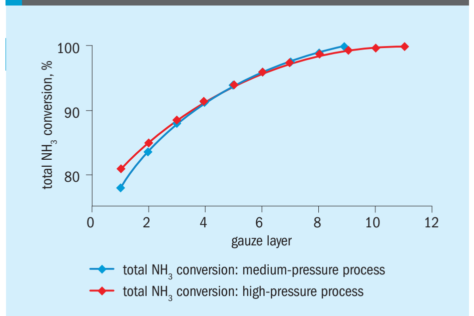


Figure 2 shows the shift of the maxima of the formation curves to significantly higher temperatures in the case of the high-pressure process. This is reflected in a correspondingly lower NO selectivity of the high-pressure process at comparable temperatures to the medium-pressure process.

Process simulation

Process simulation is used for analysis and optimisation of chemical plants and chemical processes. It is a model-based representation of chemical processes which introduces approximations and assumptions but facilitates the description of a property over a wide range of temperatures and pressures which might not be covered by real data.

Based on the reaction rates and product selectivities (of all nitrogen containing products) as a result of the modelling, it is now possible to solve the mass and energy balance in the process simulation to find the stable operating points, which are reflected in the ammonia conversion rate, temperature and yield at each gauze layer in the catalyst package. The current operating parameters are used as input values for the process simulation with respect to mixed-gas flow rate, pressure, temperature and composition.

To illustrate the effects on temperature, NH_3 conversion and selectivity, the modelled process data of a medium-pressure process are contrasted with the data of a high-pressure process (Figs 4 and 5).

The high-pressure process reveals a significantly higher temperature of each catalyst gauze layer and requires a higher number of catalyst gauze layers for complete NH_3 conversion.

This effect is primarily due to the increased flattening of the conversion curve with increasing number of catalyst gauze layers.

Process simulation enables the illustration of different operating and control conditions and predicts their impact on the productivity and efficiency of the process completely and accurately. It allows for systematic optimisation of operating conditions such as increased efficiency toward NO or surveillance of operation when expanding the capacity to avoid yield declines. In short, it predicts process data at varying input parameters.

The dynamic process simulation also takes into account time-varying conditions by the introduction of heat and mass accumulation. This allows optimisation of the start-up procedures as well as the analysis of extreme operating conditions for the improvement of process reliability and safety.

This process simulation replaces the traditional signal processing in which the process was subjected to step-like or peak-like changes. The combination of reaction kinetics modelling and process simulation makes any intervention in the on-going operation redundant in the future.

Steady-state operating points

The ignition point is the first stationary point on the heat generation curve (Fig. 6). The amount of heat generated

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Fig 6: **Correlation of heat generation/heat demand and temperature**

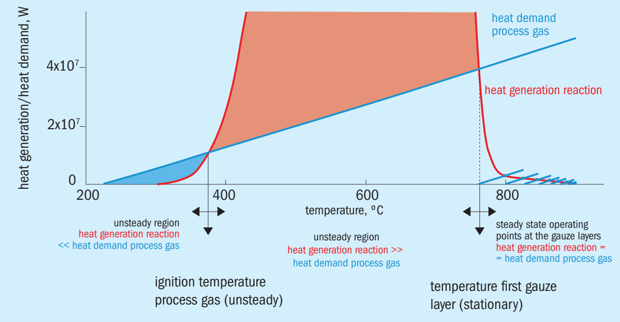
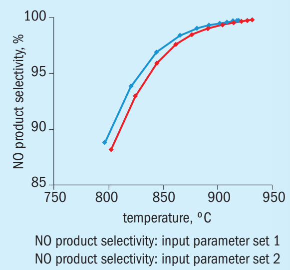


Fig 7: **Correlation of NO product selectivity and temperature for different sets of input data**



corresponds at this point to the heat demand of the process gas to be heated up to the corresponding temperature.

At all temperatures below the ignition point, the heat demand of the process gas is higher than the heat generation by the reaction. The reaction is unsteady and develops slowly, the ignition proceeds with much delay and is non-uniform over the cross section of the catalyst. The ignition of the process below the ignition point can cause a negative impact on the catalyst activity and a corresponding long time to achieve the maximum catalyst activity, respectively process yield.

Above the ignition point, the quantity of heat generated by the reaction is significantly greater than the heat demand of the process gas to be heated up to the corresponding temperature. Due to the high heat generation the reaction rate increases and shifts the process temperature towards higher values. Only the increasing ammonia consumption decreases the heat generation despite rising reaction temperature. The heat generation decreases, and runs into a steady state in which it is equal to the heat demand of the process gas. This state indicates the equilibrium condition in the first catalyst layer.

Subsequent intersection points characterise the equilibrium points of heat generation and heat demand of the process gas in the other catalyst layers. The last intersection point characterises the lowermost catalyst layer, thus defining the required number of catalyst layers in the catalyst pack for complete ammonia conversion. The corresponding process gas temperature defines the characteristic gauze temperature and thus the process yield and efficiency.

Process optimisation

Solving the mass and energy balances enables the process simulation to be used to identify stable operating points, such as temperature, NH_3 conversion and selectivity, respectively yield, as a function of the input parameters. Different sets of input parameters therefore result in characteristic different developments of temperature and selectivity in the catalyst pack and in significant differences in the overall yield of the process. Figure 7 shows the dependence of the process selectivity on two different sets of input data for a high-pressure process. The curves illustrate the lower NO product selectivity for the second set of input parameters despite higher operating temperatures.

From this overall picture, unfavourable or adverse operating conditions can be detected and opportunities for process optimisation can be derived, corresponding to the boundary conditions of the plant and its equipment.

This approach places the plant manager in a position to understand his process under the current conditions and enables him to relate to the impact of the applied process and control parameters on the productivity and efficiency of the process. This gives rise to various opportunities to optimise the process according to the individual objectives and possibilities.

The scope of amoxEXPERT extends from the improvement of the current operation under the given conditions to the development and implementation of optimised start-up, process and control parameters with the objective to:

- increase stability and security of the process;
- increase efficiency and productivity of the process;
- protect resources and equipment;
- overall reduce time, efforts and costs.

Firstly, all data which can be provided by the plant management (e.g. flow sheets) are analysed. This provides amoxEXPERT with a fairly clear overview of the varying process behaviour under prevalent frame conditions in correlation with input parameters and process control.

Secondly, on-site discussions take place between amoxEXPERT and the plant management: Current operations modes, parameters and all relevant frame conditions are looked at and discussed in order to attain a clear understanding of the objectives of the customer.

Thirdly, the process is modelled based on this analysis which provides the simulation of the prevalent process behaviour. The process simulation allows the accurate modelling of alternative operation and control scenarios and can be used to predict influences on productivity and efficiency.

In anticipation of the agreed objective of the project, the computations of the simulation illustrate in detail the deviation between the optimised and the actual process with respect to process gas and the individual plant aggregates in the flow sheet.

The plant management is always kept in the picture via project reports. This allows for spontaneous but safe reaction to altered and/or additional production objectives or frame conditions any time even during a running campaign.

amoxEXPERT accompanies supports and monitors the implementation and analyses the process behaviour until stable conditions of the new, optimised process are reached. ■

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