The fully timetabled agenda for CRU Nitrogen + Syngas 2023 will be released shortly

Highlighted technical papers and abstracts include:

Decarbonising hydrogen and syngas production

Electrified steam methane reforming by eREACT™: Emissions-free syngas manufacturing
Peter Mølgaard Mortensen; Kim Aasberg-Petersen; Yassir Ghiyati, Topsoe A/S

Topsoe's eREACT™ is the electrified evolution of the world's most common syngas-production method, steam-methane reforming (SMR). Bridging existing syngas manufacturing with renewable electricity allows for an emissions free chemical plant, built on the existing principles of the syngas platform, allowing leverage of existing hydrocarbon infrastructure or integration with other carbon feedstocks such as biogenic carbon or captured CO_2. While SMR typically generates needed heat through combustion of natural gas – which results in CO_2 emissions – eREACT™ facilitates the same reaction without the associated environmental impact. The reaction heat for eREACT™ is generated directly by (renewable) electricity, thereby eliminating the flue gas altogether. With decreasing cost of renewable electricity, this technology empowers even existing industrial complexes to electrify syngas production in a cost-effective manner.

Recuperative reforming – A key element for blue syngas production
Jan-Jaap Riegman, Technip Energies; Stefan Gebert, Clariant; Ermanno Filippi, Casale

The Enhanced Annular Reforming Tube for Hydrogen (EARTH®) for hydrogen/ syngas production and the Technip Parallel Reformer (TPR®) are two technologies for Blue H_2 that ultilise high-grade heat to minimise the energy input required for reforming. EARTH® technology is a novel recuperative reforming process. Recent successful installations and start-ups of EARTH applications in large European refineries highlight the benefits of the technology. The TPR® is a well referenced recuperative reformer where high grade heat is utilized to drive reforming reaction in parallel to main reforming section.

While traditional steam methane reforming technologies degrade high-grade process heat to generate high-pressure steam, recuperative reforming offers the possibility to utilize high-value heat to produce additional hydrogen/syngas, and/or to save energy (and operating cost) by reducing the firing duty of the reformer. The tradeoff between steam generation and energy savings may be easily optimized to meet the desired outcome.

The paper will explain the EARTH® and TPR® technology's benefits for syngas production and will showcase some recent experiences of these technologies in hydrogen plants. Additionally, it will present a flow scheme based on an ammonia plant including the impact on the Secondary Reformer and the total energy balance. The paper will finally highlight how EARTH and TPR together with Casale's proprietary ammonia technology can directly contribute to >30% CO_2 emission reduction that can further be enhanced by synergistic design modifications in the rest of the plant leading to significantly lower emissions compared to conventional scheme using steam for driven machinery.

Low carbon hydrogen: A climate silver bullet
Elena Petriaeva; Bernhard Geis, BASF

BASF's OASE® white is a proven amine scrubbing technology for deep CO_2 removal from syngas, achieving a targeted process gas CO_2 capture rate of up to 99.97 mass%. For flue gas carbon capture, OASE® blue technology was developed specifically as an optimized post-combustion capture technology with low energy consumption, low solvent losses and an exceptionally flexible operating range. Combining the two technologies, OASE® blue for flue gas CO_2 emissions capture and OASE® white for process gas CO_2 emissions capture, the lowest CO_2 footprint overall is possible. The paper also investigates potential process options to convert grey to blue hydrogen facilities, including discussion of several specific projects utilising CO_2 capture.

Blue hydrogen production: Achieving minimum carbon footprint and minimum operating cost, comparing SMR and ATR
Menica Antonelli; Stefano Carenza; Giulio Galdieri; Stefania Taraschi; Alessandro Buonomini, KT – Kinetics Technology SpA

A blue hydrogen production unit enables the reduction of CO_2 emissions by removing part of the produced carbon dioxide. The carbon dioxide is produced in the reactors, as by-product of the hydrogen production, and in the Steam Methane Reformer (SMR), as product of the combustion. The CO_2 removal can be performed either in the pre-combustion section and in the post-combustion section of the plant. Reduction of the carbon footprint is achieved by both reducing the CO_2 production and maximizing the CO_2 capture.

The selection of the most optimized configuration for a blue hydrogen production unit is not uniquely identified and it depends on several parameters. This paper will review a case study of a blue hydrogen production unit to select the optimized plant configuration. A particular focus will be given on plant CO_2 footprint target and on related OPEX, with the case study illustrating the sensitivity analysis when comparing two technical solutions. The case study refers to a blue hydrogen production unit with 120.000 Nm^3/h capacity: one plant configuration is based on Primary Reformer (SMR) only and the other is based on Primary Reformer (SMR) followed by Secondary Reformer (ATR).

Reducing the carbon footprint of ammonia and methanol production

The best of low carbon hydrogen technologies for ammonia
Martin Gorny; Sophia Schmidt; Sayan Dasgupta, Air Liquide Engineering & Construction
This presentation will identify the process steps with the highest impact on CO_2 intensity of ammonia, and different technology options for these will be discussed. Based on the discussed rationale, a comprehensive and optimized technology chain for low carbon ammonia production will be presented. The suitability of Air Liquide E&C's oxygen-blown ATR, which, to date, has predominantly been used in methanol production will be presented. Due to its inherent advantages for carbon capture, availability of all CO_2 at high pressure, its relevance for low carbon syngas production is increasing. The ATR for syngas production can be coupled with two CO_2 capture technologies: CryocapTM H2, a referenced cryogenic CO_2 separation technology, which is suitable whenever abundant electricity is available or high CO_2 purity is required; Alternatively, RecticapTM, the RectisolTM tailored for CO_2 capture only. This syngas preparation can then be coupled with any ammonia synthesis technology to deliver an energy and cost efficient low carbon ammonia product.

Blue NH_3 with HISORP CC: An adsorptive CO_2 removal process
Thomas Ried, Linde

Linde has developed a new CO_2 removal process called HISORP CC, which is based on pressure swing adsorption (PSA) technology. CO_2 is a strong adsorbing compound on most commercially available adsorbent materials and can effectively be separated from other compounds like H_2, N_2, CO or CH_4. The PSA offers a simple and very robust process unit without the usage of chemicals. Unlike absorptive

CO2 removal processes, like amine-based washing units, no steam is required for the adsorbent regeneration. As no extra steam production is required, no additional CO2 is emitted. CO2 purities between 90 and even above 99.9 Vol-% can be achieved, following the requirements of utilization.

According to the Linde Ammonia Concept, the syngas for the NH3 synthesis is generated by pure H2 and N2. The H2 can be produced by all different production technologies, such as steam reforming, partial oxidation (POX), by autothermal reforming (ATR), and also by electrolysis. The N2 is provided by an air separation unit (ASU). In order to produce blue NH3, CO2 from the fossil-based production process needs to be separated and sequestrated. If the ASU runs on green power, no extra CO2 removal related to N2 production is required. For all conventional H2 production methods except for electrolysis, CO2 is emitted by firing carbon containing fuels. Depending on the H2 production process set-up, carbon capture rates even above 95% are feasible applying HISORP CC. HISORP CC can be applied at three different positions in the H2 production process: In the syngas, after the CO shift; in the H2-PSA tail gas; or, in the flue gas

The presentation will focus on the general HISORP CC concept. Additionally, the pros and cons for the different positions of the CO2 removal in the H2 production route will be discussed. Moreover, typical carbon capture rates of the different HISORP CC options will be presented.

Reducing CO2 footprint and increasing ammonia production via injection of green hydrogen into existing ammonia plants
Frederick Kessler; Bernd Mielke; Klaus Noelker, thyssenkrupp Industrial Solutions AG

The possibilities to reduce the CO2 emission of existing ammonia plants are very limited if the plant already has a relatively good energy efficiency. One option is the replacement of a part of the natural gas feed by green hydrogen, that means, hydrogen coming from electrolysis of water, using electricity from renewable sources. Besides the effect of a specific reduction of CO2 emission of ammonia production, the additional hydrogen can also serve for a capacity increase.

Fertiglobe has implemented such capacity increase measures based primarily on the addition of Green Hydrogen to its three ammonia plants at its fertilizer production complex at EFC in Ain Sokhna, Egypt. The future overall goal of transforming the existing gray ammonia plants into truly hybrid (green / gray) ammonia plants by further capacity increase coupled with the reduction of natural gas usage will continue on the same path that was already started during the initial phases of the project.

This paper will describe the measures that were taken in order to achieve the initial introduction of the green Hydrogen into the ammonia plant, as well as measures that are still planned in order to further increase the capacities of the ammonia plants, while simultaneously reducing their carbon footprint. Challenges and lessons learned from the retrofit, particularly in respect to the change of flow rates, temperatures and compositions in the reformer area will be shared.

Barents blue ammonia project: A landmark towards sustainability
Massimiliano Sala; Andrea Zambianco; Bjørgulf Haukelidsæter Eidesen, Saipem

Horisont Energi has an ambitious plan to develop a large-scale blue ammonia complex in Finnmark, Norway exploiting the favorable combination of abundant feedstock gas, cold climate conditions which allow higher process efficiency, and proximity to offshore CO2 storage. Saipem’s consolidated background in the execution of ammonia projects worldwide is supporting Horisont Energi’s vision with project tailor made solutions.

This article describes the main Barents Blue Ammonia Project features such as 99% carbon capture rate target, high degree of modularization, winterization, infrastructure for ammonia and CO2 management and provision for future expansion.

How optimal integration of SOEC electrolysis and Topsoe ammonia technology can significantly impact plant economics
Christian Wix, Topsoe A/S

One of the inherent challenges of power to X plants, including green ammonia, running on renewable energy sources is managing significant load variations.

This paper will cover how the electrolysis section will handle load variations in the renewable energy input. It will also cover how to effectively operate the ammonia loop at various loads and with rapid changes in the load. These areas are both very important for the CAPEX and OPEX for a new green ammonia plant.
This paper will highlight some of the challenges in designing and operating a green ammonia plant optimally. It will also illustrate some of the solutions as to how to optimally integrate the ammonia plant and the SOEC electrolysis, and how to operate optimally with large load variations.

Blue ammonia for lower CO2 emissions
Klaus Noelker, thyssenkrupp Industrial Solutions AG

Reforming-based ammonia production has two places of CO2 emission: The CO2 removal from the process gas and (with a smaller quantity) the reformer flue gas. The major part of the CO2 comes sequestration-ready since the CO2 has to be removed from the process gas anyway. Instead of venting it to the atmosphere, the additional effort for CCS is just the compression for export. This unit can also be added to any existing ammonia plant, thus lowering its CO2 emission by about two thirds already.

However, further reduction is possible by also treating or lowering the flue gas from the primary reformer or – in case of an autothermal reformer (ATR) plant – from the fired heater. Several technologies, suitable for new plants and as a revamp, exist for such CO2 removal.

For an ATR plant, reduction of the CO2 emission by more than 90% can be achieved also without the costly installation of a CO2 recovery unit. Uhde presents a process which replaces this costly post-combustion method by a pre-combustion technology, which is usage of hydrogen-rich gas from the process as heater fuel.

Tangible solutions to face the challenge and implement a sustainable transition: Casale technologies for emission reduction in existing plants and newbuilds

Francesco Baratto, Casale SA

This paper will present the suite of Casale products for emission reduction via retrofit of existing plants. Solutions for both blue and green newbuilds will be explored. Tchnologies and solutions are described step by step, considering the different project context and the relevant impact on the economics. It will demonstrate how emission reduction is not necessarily an additional cost for plant owners; conversely, it can be turned into a profitable investment in the wider decarbonisation journey.

Improving efficiency and production of ammonia/urea plant with co2 valorisation strategy
Mohamed Abdel Atty; Ahmed Maria; Salah Mahdi, MOPCO

MOPCO have developed a roadmap to define opportunities for energy efficiency while decreasing the carbon footprint at their ammonia /urea plant, with the objective to reduce natural gas consumption and decrease the plant's carbon footprint by approximately 35000 tons CO2/year by 2025. To valorise the CO2 from primary reformer, MOPCO have started to execute a strategy that converts CO2 (0.7 Tco2/ TNH3) from capturing unit to increase the urea plant load from 1925 to 2150 tons per day.

By integrating the existing ammonia plant with the strategy, MOPCO will add 50 tons per day of green ammonia production to finance the project. Utilizing a renewable energy source from the national electrical grid, green hydrogen will be produced via electrolyzer with increasing the operating pressure for hydrogen to suction the existing syngas comp. A future component of the plan will include a small methanol production unit that will be built together with the increase in urea plant load to get benefit from the carbon dioxide that can be recovered from the primary reformer stacks.

TrueBlue Methanol™ - A low carbon emission methanol production process
Dan Barnett, BD Energy Systems LLC

BD Energy Systems LLC introduces TrueBlue Methanol™, an innovative low carbon emission methanol production process that utilises proven techniques to achieve greater than 90% reduction in the emission of CO2 from the stack of the Steam Methane Reformer [SMR] furnace while producing methanol with an overall energy consumption that is competitive with even the newest operating SMR-based methanol plants.

The TrueBlue™ process can be implemented not only on grassroot and relocated methanol plants but as an upgrade to existing methanol plants for any natural gas fed process configuration.

This process delivers a product CO_2 stream using an amine-based CO_2 removal system placed upstream of the methanol synthesis reactor. Doing so reduces the consumption of hydrogen in the methanol synthesis process, resulting in greater hydrogen availability for SMR fuel. The use of a pressure-swing-adsorption [PSA] unit on the methanol synthesis loop purge stream recovers hydrogen from that stream for use as SMR fuel, and recompression of the carbon containing PSA tail gas allows recycle of most of that tail gas to the SMR feed. This recycle results in more complete conversion of incoming feed to synthesis gas and effectively reduces SMR stack gas CO_2 emissions to a very low level.

New developments in renewable energy technology

KBR Ammonia Cracking Technology: A roadmap from renewable energy source to green hydrogen supply where it is needed the most

Henrik Larsen; Elena Stylianou, KBR

Green hydrogen is earmarked as the renewable fuel of the future while green ammonia offers a flexible, high energy density solution for storage and distribution, utilizing existing and reliable infrastructure. The advent of ammonia cracking technology, dissociating green ammonia back into green hydrogen, completes the missing link in the roadmap to sustainability, enabling the production of green ammonia where the renewable energy is abundant with the ability to supply green hydrogen in locations with high demand but low availability of natural resources to produce it.

KBR has successfully developed a competitive ammonia cracking technology, high efficiency and able to meet stringent environmental requirements on carbon emissions, targeting moderate to very large-scale capacity green hydrogen production.

This paper presents the KBR technology roadmap from renewable energy to green hydrogen supply where it is needed most, highlighting the process steps, the efficiency achieved, while completing the ammonia to hydrogen value chain without emitting any CO_2.

Syngas processing in waste-to-renewable energy technology with reduction of CO2 footprint

Zbigniew Urban, Siemens Process Systems Engineering Ltd.

The processing of organic material from growing landfills of domestic and other types of waste is important because it can significantly reduce CO_2 emissions and secretion of chemical toxins whilst contributing to meeting current demands for renewable energy.

This presentation considers the integration of three disruptive technologies aiming to achieve these objectives while allowing the production of automotive grade hydrogen and/or zero sulphur jet fuels within a very low CO_2 footprint:

- Pure, high temperature pyrolysis of waste material with no partial combustion
- Fischer-Tropsch synthesis with 80% single-pass conversion of carbon monoxide and 80+% of hydrogen
- Plasma torch for decomposing methane and light hydrocarbons to hydrogen and carbon black or for conversion of CO_2 and hydrogen to syngas.

The above are combined with standard, established gas processing components including the UOP Benfield process, catalytic methanation of CO_2, and high- and low-temperature Water Gas Shift reactors.

The three new technologies have been studied individually in experiments at pilot or demonstration scale.

Based on these experimental data, a simulation study of the integrated plant has been carried out, the results of which will be shared.

Emissions reduction

Effective reduction of nitrogen oxide and ammonia emissions by utilizing environmentally compliant technologies
Tomohiro Otani; Shinya Fukuzawa; So Akimoto; Masahiro Hayashi; Ryota Shimura, Mitsubishi Heavy Industries Engineering, Ltd
Husen Saidov, Navoiyazot JSC

This paper will demonstrate how Mitsubishi Heavy Industries Engineering, Ltd. (MHIENG), utilized a distinct set of emission-mitigating technologies to reduce NOx and ammonia emission level in Uzbekiztan Navoiy Fertilizer (UNF) Plant.

MHIENG applied the Selective Catalytic Reduction (SCR) technology by Haldor Topsoe A/S (HTAS) for Primary Reformer, Non-Catalytic Reduction of NOx contents for Auxiliary Boiler and Acid Scrubbing System for ammonia reduction in Granulation Plant. The combination of these systems to reduce environmental impact is not commonly found among fertilizer plants.

To guarantee the effectiveness of the installed technologies, their performance was evaluated. By installing the SCR type-DeNOx system in the reformer, NOx emission was reduced to less than the expected Vendor's design limit of 25 mg/Nm3 (at 3.0 vol% O2, as dry NO2). Emission reduction ratio of about 80% was achieved. Likewise, for Auxiliary Boiler, adequate NOx reduction up to less than 40 mg/Nm3 was achievable using low NOx burner with simultaneous steam injection and Flue Gas Recirculation (FGR). This was equivalent to 80% reduction when compared to a blank case - without steam injection and FGR.

For the Urea Granulation Plant, ammonia emissions were reduced to less than 20 mg/Nm3, achieved using the Acid Scrubbing system. This was below Vendor design figure of 50 mg/Nm3. The 20 mg/Nm3 result, being compliant with IFC ammonia emission standard of 50 mg/Nm3 could clear the strict standards of foreign countries such as United States of America. Moreover, dust emission was also tested to be only 15 mg/Nm3 versus the design point of 50 mg/Nm3.

The combination of SCR DeNOx Unit, non-catalytic NOx reduction method and Acid Scrubbing system as applied by MHIENG in UNF Project are proven to effectively reduce nitrogen oxide and ammonia gas emissions respectively way beyond the standard criteria.

Asset integrity and process safety

Pressure equipment failures on ammonia and nitric acid plants from stress relaxation cracking
David Keen, Becht

Equipment operating at elevated temperatures in ammonia and nitric acid plants can be susceptible to a damage mechanism termed 'stress relaxation cracking' (SRC). This paper outlines:
• An overview of actual case studies where SRC failures have occurred leading to plant downtime and potentially putting plant personnel's safety at risk.
• A summary of key contributing factors which lead to equipment failures from SRC.
• What preventative controls need to be put into place during the design and construction stage to prevent SRC from occurring.
• What do we need to do to ensure this potentially serious damage mechanism is always included in our design & risk analysis processes?
• How the potential for SRC can be recognised during an RBI assessment and what inspections need to be put into place as failure preventative controls.
• How to repair equipment which has suffered a failure due to SRC.

Stress relaxation cracking requires the presence of high stresses either residual and/or applied, and therefore is more likely, but not limited, to occur in thicker sections and higher strength (creep) materials. SRC occurs at elevated temperatures when creep ductility is insufficient to accommodate the strains required for the relief of applied or residual stress(es). Several case studies will be shared.

Creep Life Assessment of Non-Standard Materials: Reformer Tubes and Outlet Manifolds
Charles Thomas; Tim Hill; Alice Young, Quest Integrity

Methods used to assess the fitness for service and remaining life of high temperature components are well established and embodied in codes such as API 579 “Fitness for Service”. These approaches assume that the relationship between applied stress, temperature and time in service remains constant over the life of the equipment while accounting for some material property scatter from batch to batch. There are a number of materials however for which this appears to be not the case.

The stability of material creep properties will depend upon the metallurgical details of how any given material develops its creep resistance. For many materials this does not change significantly. But for a few key materials such as those used for reformer tubes and outlet manifolds, this is not the case. At the same time as creep damage accumulates, the creep strength of the material deteriorates or ages in service due to long term exposure to high temperature. This is in effect an extremely elongated heat treatment.

This paper describes how this process influences the strength of the materials used to manufacture reformer tubes and outlet manifolds and how the continuously changing creep properties can be incorporated into modified methodologies to provide reliable estimates of remaining life. Such methodologies provide confidence that the extremely large capital cost associated with tube and manifold replacement can be confidently deferred or enacted at the right time.

Optimising the production of nitric acid

Start me up – improved activation can improve gauze performance
Thomas Ithell, Johnson Matthey

The start-up of a nitric acid plant can have a significant influence on the performance of the ammonia oxidation gauze catalyst over the duration of the campaign. A successful light off will ensure the rapid restructuring of the gauze surface to maximise conversion efficiency early in the process, whilst avoiding the formation of an ammonium nitrate or creating an explosive atmosphere.

This paper ‘Start-up 101 paper’ reviews a range of start-up learnings and the parameters, including rate of ammonia addition to the process, controls and monitoring of the gauze during start-up, and sources of contamination, and discusses the impact these variables can have of gauze performance and plant safety including review of how offering includes products that can offer the following features - enhanced light off, reduced rhodium oxide formation and lower OPEX costs.

Optimization of ammonia oxidation by CFD modelling and experiments. Role of mass transfer on product selectivity
Artur Wiser, Umicore

After 100 years the Ostwald process is still the most common way for the industrial manufacturing of nitric acid. The process is divided into three steps, the first step is the catalytic combustion of ammonia with air towards nitrogen monoxide, with the by-products being N2 and N2O.

As catalyst, mainly Pt-alloy gauzes are applied with different compositions and structures. Although the process is well known, and highly optimised, knowledge of the influencing factors and kinetic details under realistic conditions is limited due to the harsh conditions (up to 1000 °C, corrosive atmosphere) and the mass transport limitation of the reaction.

This paper will demonstrate how a very established but very complex chemical process like Ostwald process can be improved using new modelling and experimental techniques. The main focus will be the investigation of product selectivity (NO, N2 and N2O) on different process conditions tin a lab scale reactor and using CFD-simulation. Based on this knowledge, new optimized gauze structures are design and tested in the industrial environment. The newly developed and optimized catalytic gauzes for ammonia oxidation can significantly increase the efficiency of the process, by reducing NH3 consumption, and reducing N2O emissions, yielding improvement in production economics.

Optimized FTC Flex Gauze Packs For Catalysis Of Ammonia Oxidation
Oliver Henkes, Heraeus Deutschland GmbH & Co

For nitric acid production, each catalyst gauze design has to be tailored to the operating conditions of a specific plant and to the market requirements perceived by the customer. The most important cost factors which are influenced by the market development are the NH3 prices, precious metals costs and nitrous oxide emission prices in certain regional areas.

This paper will introduce the latest development of the Heraeus FTC Flex concept, which takes into account not only plant operation conditions but also cost factors arising from market conditions to provide the gauze design with the best economic benefit for nitric acid plants. Considering the catalyst reaction kinetics, the gas flow dynamics, and the changes of catalyst micro-surfaces during the operating time, the catalyst CFD simulation software enables to find the best alloy composition and the best 3D geometric structure of each gauze type located at the different positions from top to bottom of a catalyst gauze pack.

Heraeus FTC Flex gauze packs offer the possibility to reduce N2O emissions by primary abatement. The primary N2O abatement with the catalytic gauze pack is fully customizable, making it suitable for both full and partial loads. By using Heraeus FTC Flex gauze packs in combination with Heraeus iron oxide-based secondary catalyst, average nitrous oxide emissions in the tail gas of medium pressure plants of less than 50 ppmv can be achieved. This catalyst combination is used successfully in many nitric acid plants worldwide.

The new development FTC Flex gauze packs takes into account plant operating conditions and cost factors of market conditions to provide the gauze design with the best economic benefit for nitric acid plants. FTC Flex gauzes in combination with secondary catalyst help to achieve continuous improvements for the benefit of Heraeus customers.

Predicting precious metal recoveries from nitric acid plant cleaning
David Kelly, PGM Technologies
Gle Park, KBR

For nitric acid producers, estimating precious metal recoveries from heat train components and tanks is just as predictable as estimating precious metal losses from the installed catalyst pack. Many items factor into these estimates such as temperature exchange, location of the vessel in the heat train, surface area of an exchanger, etc. KBR and PGM Technologies are now working together to provide customers performance based guarantees for precious metal recoveries. This paper will go into the logic and technical expertise used to determine recovery estimates for cleaning entire facilities, individual heat exchangers and tanks. The paper will also address different cleaning methods and their predicted outcomes.

Latest Improvements in the Uhde EnviNOx® Process for N2O abatement
Alexander Sasonow; Meinhard Schwefer; Daniel Birke, thyssenkrupp Industrial Solutions

The EnviNOx® process, developed in the mid-2000s has been successfully installed in more than 30 HNO3 plants around the world. The process was originally intended solely for the abatement of N2O and NOx in the tail gas of HNO3 production plants, with the N2O reduction being achieved either through catalytic decomposition or selective catalytic reduction with hydrocarbons. The EnviNOx® system toolbox comprised, for example, alongside the commonly known EnviNOx® variants 1 and 2 (NOx reduction combined with N2O decomposition or reduction using hydrocarbons), a plain DeNOx variant and a plain DeN2O® variant.

Driven by increased demand and special customer requirements, the EnviNOx® toolbox has been systematically expanded in recent years. For example, the use of NH3 as a reducing agent for N2O as an alternative to fossil hydrocarbons, or the coupling of the tertiary EnviNOx® process with catalysts for the secondary decomposition of N2O in the process gas of HNO3 production plants. The progress and developments achieved are presented and explained, by way of example, based on recent successful installations of selected commercial EnviNOx® plants.

Plant economics

Syngas plant feedstock conversion: Utilising alternatives to natural gas
Kevin Mowbray, Johnson Matthey

Many operators are considering utilising alternative feedstocks switching from natural gas to heavier feedstocks such as LPG. An operator having the ability to switch between different feedstocks to minimize operating costs, improve plant operability and utilize the available hydrocarbon streams is an advantageous position.

Traditionally the installation of a pre-reformer into the flowsheet upstream of the steam methane reformer has given the opportunity to switch between different feedstocks, though retrofitting a plant comes at higher cost and the implementation can take several years from study to commissioning.

Changing the feedstock from natural gas to heavier feeds such as LPG, has many implications and challenges. Several catalyst duties can be affected and the impact of a heavier feed needs to be considered to ensure effective operation of these duties. The purification and steam methane reformer duties are key when considering switching to heavier feedstocks, along with the heat integration balance across plant.

JM has experience in assisting our customers evaluate the impact of a change in feedstock and can recommend a range of catalyst and process modelling solutions to enable efficient and effective operation.

The effects of changing feedstock from natural gas have been assessed to identify the implications for an existing Syngas plant using heavier feedstocks. Some of the possible revamp requirements and options are considered also. The outcome is designed to provide plant operators with a guide to aid decisions about changes to hydrocarbon feed type.

Ammonia operations: Converters

Experience with repair and replacement of the second ammonia converter (r-0502) in the ammonia plant-1a of Pupuk Laltim Fertilizer
Anindito Priyambudi; Yudhistira Perdana Putra; Majus Luther Sirait; Akhmad Sajidin; Abdurrachman Naim, Pupuk Kaltim

Plant-1A is one of the plants in Pupuk Kaltim Fertilizer Company. Built in 1999, is has 2000 MTPD ammonia production capacity, using Topsoe technology with two ammonia converters. The second ammonia converter, R-0502, experienced two failures in November 2017 and February 2019, in the form of cracks on its bottom head. In July 2020, the second ammonia converter unit was replaced. This paper explains the causes of failure and methods employed for repair, and the experience replacing the converter. Furthermore, the performance of the plant afterwards will also be shared.

Case study: Ammonia converter troubleshooting
Mohamed Abdelatty Ahmed; Mohamed El-Gharbawy, Misr fertilizers production CO. (MOPCO)
This paper describes a scenario where the ammonia converter experienced rapid synthesis catalyst activity decline seen causing instability of the loop and plant production decline.

The instability was first seen with a rapid temperature oscillation throughout the reactor. Investigation showed that a problem in the syngas centrifugal compressor lubrication circuit had caused contaminants (oil) carry over with the fresh feed. After discovering the reason of loop disturbance and dealing with the loop parameters, full production was restored gradually in a short time. Software-aided modelling has been executed to allow an assessment of the catalyst and loop performance.

Oil entrainment with feed at high temperatures for a time can affect the catalyst crystal lattice stability and catalyst deactivation may occur with an increase in pressure drop. The plant has now operated over 10 years with the same ammonia charge this incident having occurred over 7 years ago in 2015.

As well as the learning from the incident the paper will review some of the changes to ammonia catalyst that are being considered to further improve conversion in systems using Green Hydrogen as is going to become commonplace in Egypt.

The subsequent effect of Leakage Found in Ammonia Converter Effluent on Ammonia, Urea, and Utility Plant.
Zuhroni Ali Fikri; Indrawan Pinandita, Petrokimia Gresik; Baqir Assegaf, Pupuk Indonesia Holding Company

Ammonia Plant 1A in Petrokimia Gresik went through a start-up in October 2021 after a short shut-down due to a gas shortage. The day after start-up, the conductivity value on the steam drum taken from the blowdown point was found 145 us/cm from the normal 20 us/cm. It continued to hold the same high number after several months of sampling.

Afterwards, several problems were found simultaneously in ammonia, urea, and utility plants:
- In the ammonia plant, increasing vacuum pressure restricted the back-end rate from 90% to 85% due to the increasingly high-pressure steam consumption in ammonia plant turbines
- In the urea plant, the stripper performance fairly depreciated thus NH_3 outlet stripper increased from normal 12,5% to 15%, impacting the urea plant production rate, which was reduced to 90%;
- The utility plant was affected by the quick saturation of the mixed-bed polisher on the water treatment plant, requiring regeneration after 20 hours of operation, where it had previously operated for 6 days.

The RCA study initially focussed on the high conductivity value found on the steam drum. Any plausible causes of high conductivity were gathered to be analysed further. It was found later that the most probable cause of high conductivity is the presence of ammonia in the steam system. 171 ppm of NH_3 were found in the steam outlet of the steam drum, even after the injection of NH_3 had been halted. Non-condensable gas was also found in the steam system, located in the inter after condenser of the turbine surface condenser of the ammonia plant. The hypothesis was that the ammonia could only come from the leakage in the ammonia converter effluent – which was confirmed after another shut-down. This paper will demonstrate how the prominent cause was discovered and the ensuing modifications/repair that has been done.

Reformer optimisation

Seeing inside the box: REFORM CMS innovation in reforming monitoring and optimisation
Chris Murkin; Johnson Matthey
Dave Brinkmann, OnPoint Digital Solutions, LLC

Optimising the primary reformer is key to making ammonia as efficiently as possible, with ca. 30% of the natural gas consumed by driving the reforming reaction.

Johnson Matthey has proprietary models such as REFORMTM developed and tested over decades in industry, that take account of many parameters that contribute towards this optimisation. However, accessing real data has been a barrier to continued sustained optimisation in the field.

Utilizing OnPoint's ZoloSCANTM, TDLAS technology, makes continuous in-situ flue gas analyses achievable. This paper details how when coupled with reformer imager data providing insight into the tube wall temperature profiles across the reformer, and process data it has enabled benefits such as lowering fuel demand, excess air, and so with-it NOx emissions and CO_2 footprint.

Improving the energy efficiency of ammonia plant operations

Case study: Decreasing energy consumption during turn-around
Harnomo Teguh, PT Pupuk Kalimantan Timur

The Kaltim-2 Ammonia Plant was commissioned in 1984 with a 1500TPD capacity. It was revamped 1999 when capacity was increased to 1800TPD. Today, the plant reliability index (PRI) >96%, but efficiency and productivity have decreased, and the plant has high energy consumption at 39,11 mmbtu/ton ammonia product and production of 1796TPD. This inefficiency is due to the more wasteful use of fuel natural gas in primary reformer.

A routine turn-around was conducted from December 2019 to January 2020 and included the following improvements:

- Primary Reformer 101-B (total replacement of catalysts and 504 primary reformer tubes, replacement MKJ-MKL coil convection, dry ice cleaning MKF-MKN coil convection, air blow cleaning MKK-MKM coil convection, repairing and cleaning distributor-primary air register of arch burner)
- Repair of leakage in methanator feed pre-heater 104-C, ammonia converter feed/effluent exchanger 121-C and control valve HV-27.
- Replacement of turbine rotor syngas compressor 103-JT.
- Cleaning marine plate heat exchanger and retubing turbine condenser

Upon completion of the turn-around production increased from 1796 tons per day to 1840 tons per day and decreased energy consumption from 39.11 mmbtu/ton to 37.16 mmbtu/ton.

LTS catalyst ShiftMax217® has generated significant monetary benefits through increased energy efficiency
Maximilian Aigner, Clariant

ShiftMax®217 is Clariant's current generation of low temperature shift (LTS) catalyst. The catalyst is based on a Cu-Zn system which was optimized for mechanical stability and robustness while maintaining a high long-term activity for water-gas-shift (WGS) reaction.

In this paper, we will illustrate the benefits of ShiftMax®217 based on plant data from our customer Yara, Sluiskil. We will show that the high long-term activity of ShiftMax®217 enabled our customer to significantly increase energy efficiency of the ammonia plant.

The catalyst was taken on stream in December 2020 and showed good performance regarding WGS conversion with low methanol (MeOH) formation. In May 2022, Yara decided to reduce inlet temperature of the LTS reactor to benefit from the more favorable carbon monoxide equilibrium (CO) value. This measure would in return enable reduced steam input to the steam reformer (SMR). After reduction of the inlet temperature to the LTS reactor, the CO value dropped and enabled the operators to reduce steam input to the SMR. This resulted in a decrease of the steam-to-gas ratio at LTS inlet, which in turn increased the CO slip to the original value.

Based on catalyst performance evaluations and kinetic studies conducted by Clariant, this measure resulted in an overall energy reduction at the SMR of ~7 GJ/h. Yara confirmed this theoretical value with the reduced demand for fuel gas at the SMR. In face of current gas prices in Europe, this measure was a great success and increased the energy efficiency of the plant significantly.

The underlying requirement for this measure to be beneficial is a catalyst that is active enough to reach the more favorable CO equilibrium at an overall lower temperature level and not run into a kinetic limitation. Most remarkable is the fact that the reduction of inlet temperature was performed after 1.5 years of operation. Thus, the high robustness and long-term activity of ShiftMax®217 set the basis for this process improvement to be a success.

Benfield System Revamp experience at Yara Plant
Vinod (VK) Arora, Kinetics Process Improvements Inc (KPI)
Waqar Khan, Yara Belle Plaines Inc

This paper will be jointly presented by Yara and KPI to share the experience and lessons learnt of a major revamp of Benfield CO2 removal system of Ammonia plant (~2100 MTPD) at Yara Belle Plaine in Canada.

The operation of the Benfield system was stretched to its limits at its current capacity with various limitations. A holistic review was carried out by KPI in 2019 which included the complete simulation modelling of the existing Benfield system along with evaluation of all the major equipment to quantify the limitations. Following the review, the decision was taken to replace the existing equipment with new design conditions, including:

- New Flash drum
- New Ejectors
- New Reboiler
- New Liquid distributors in Absorber and stripper
- Modification of the collector box to improve reboiler circulation & hydraulics
- Modifications of the Feed drum

All the above modifications & the new equipment were mechanically completed in Aug-2022 and plant restarted with those changes. This paper will share the new performance and the lessons learned for this important revamp of the Benfield system, which include improvements to energy efficiency and reliability of the plant.

First commercial references of the new award-winning ammonia synthesis catalyst AmoMax-Casale®
Francesco Baratto, Casale
Nikola Georgiev, Clariant

Improvements in ammonia synthesis catalyst performance can significantly improve plant energy consumption by reducing the requirements of the synthesis gas compressor and refrigerant section of an ammonia plant.

AmoMax®-Casale is a new ammonia synthesis catalyst jointly developed by Casale and Clariant, particularly for use in Casale ammonia converters. AmoMax®-Casale is a customized evolution of the industry-proven, wustite-based catalyst, AmoMax® 10, and is significantly more active. This feature allows a reduction in the loop recycle rate and the loop pressure, which reduces CO2 emissions and/or allows an increase in ammonia production.

This paper will provide details of the performance of the first references of AmoMax-Casale catalyst in large-scale ammonia plants. Based on real plant data, it will show how the superior performance of this innovative product leads to lowered production cost through energy and cost efficiencies. At the same time, it added the benefit of lower CO2 emissions and improved plant sustainability.

Urea operations

Sustainable urea plant operation during stripper ferrules (liquid dividers) unavailability and & in-house repair of stripper ferrules
Sabeeh Ahmed; Qaisar Imran, Fatima Fertilizer Company Limited

This paper details how FFL were able to sustain operation of their urea plant while the plant experienced the failure of the high pressure stripper ferrules (liquid dividers). It will also detail the in-house repairs that were made to allow these available for re-use.

The FFL urea plant high pressure (HP) equipment has Safurex lining and internals. The plant was commissioned in 2010, and a second inspection of HP Equipment was carried out during turnaround in

2015. During inspection, erosion & thickness loss was observed in the HP stripper ferrules (liquid dividers) but within acceptable limits. Based on observations during the 2015 turnaround, the next inspection was planned for 2019.

During Q3 2017, FFL experienced an issue with degrading efficiency of the HP stripper. Based on the thickness loss observed in the 205 turnaround, it was hypothesised that ferrule failure was the probable cause. The poor performance of the stripper impacted the synthesis section, causing lowered conversion and poor steam generation, as well as overloading the downstream section. ΔT across stripper also reduced from normal operating valve of 15~17 oC to 5 oC. In addition, the high temperature of the urea solution meant it was operating close to downstream section design temperature. As no spare liquid dividers were available, the plant continued to operate despite these challenges until the planned turnaround in 2019.

A full inspection of stripper was carried out during the 2019 turnaround, where elongation was observed at the liquid divider holes along with severe corrosion & cross cut the on conical portion. The liquid dividers conical portion had detached from the tube due to a cut along the cross section due to corrosion attack, which had compromised the functionality of the liquid dividers. During the turnaround, 40% of the ferrules were repaired and re-installed, with the remaining 60% replaced with new ferrules. The repaired ferrules have successfully remained in operation for 3 years.

The paper will detail how plant operations were maintained during the ferrule failure, and detail the repair and replacement procedure.

A Blocked Leak Detection System: What to do?
Mark Brouwer; Jo Eijkenboom, UreaKnowHow.com

The presence of a reliable leak detection system in lined High Pressure urea equipment is a must. Only an active leak detection system acts in a sufficient reliable way. Leak detection systems should be tested before installation, after a shut down and weekly during operation to ensure communication between the holes of each liner compartment.

A leak detection system should be always in operation especially during stops, startups and shutdowns in order to minimize the risks for blockages. Once a leak detection system is blocked, restoring communication will be difficult and depends strongly on the location of the blockage. In case of a liner leak the risk for any permanent blockage is present. A vacuum leak detection system is the only leak detection system that guarantees a reliable leak detection in all operating modes (stop, start and shut down) and in case blockage behind the liner has occurred.

Carbamate solution carryover during urea plant startup
Gelar Panji Gemilar; Alfin Ferdiawan; Zuhroni Ali Fikri, Petrokimia Gresik

In October 2020, the Petrokimia Gresik Urea I B Plant experienced a start-up process failure in the synthesis section. After the reactor overflow step began, synthesis pressure instability was observed, followed by ammonium carbamate solution carryover from the carbamate condenser vent into the Flare system. The liquid separator in the Flare system was unable to handle excessive carbamate solution, therefore solution overflow from the system occurred. To minimize safety risks, the startup process was stopped, and solution transfer from synthesis section to the carbonate solution tank was performed immediately.

The startup failure investigation found the issue was with incorrect readings from the reactor and carbamate condenser radioactive level indicator: The reading level indicated that the level was constant at 88% while the actual level was more than 100%. This condition caused the operator incorrectly continuously feed recycled carbamate solution and fresh ammonia to the synthesis section until carryover happened. This problem was resolved by resetting the power of the level indicators. After resetting the power, the level reading returned to normal, and the startup process was recommenced. Following this experience, Gresik have modified the startup procedure by adding a reactor and carbamate condenser radioactive level indicator power reset before the feeding process and monitoring the top and bottom stripper temperature during startup as the second layer of carryover indicator.

Optimizing explosive mixture in a vintage urea plant to enhance production capacity and energy efficiency for sustainable operation

Luqman Rafiq; Arshad Naveed; Muhammad Waqas Quraishi, Engro Fertilizers Limited

Environmental and energy efficiency is the key to achieve an optimized urea manufacturing process. However, process safety is another important parameter and often a trade-off between the two parameters is required to achieve a sustainable and safe process. This document incorporates a case study of a vintage urea plant where abatement of greenhouse gas emissions was carried out while providing inherently safe alternative in the form of excess steam to avoid formation of explosive mixture at vent stack of urea plant. A detailed study and a test run comprising over a span of 5 months was conducted which resulted in urea production increase, 0.1 MMBTU/MeT urea energy index improvement and 0.49% improvement in site carbon footprint number. This paper also discusses different alternatives to avoid formation of explosive mixtures which are energy efficient and environment friendly that can be beneficial for the industries operating in the same capacity.

Lessons learned from replacing a HP stripper and HP scrubber during turnaround

Ahmed Ibrahim; Ahmed Abdelaziz; Abu Qir

In May 2022 Abu Qir replaced the HP Stripper and HP Scrubber during their urea plant turnaround. The plant had previously conducted an unplanned turnaround in 2018 due to the failure of the HP Scrubber. At the time, the estimated remaining life for the two vessels was almost three years, at which point a full replacement was advised by the licensor.

This paper will detail the fabrication of the two vessels; pre-turnaround activities; shut-down and start-up; and pre-commissioning. Challenges and lessons learned will be shared, as will the results of the turnaround, including improved steam consumption.

Improving the performance of the HP synthesis and wastewater treatment sections of IFFCO Kalol

Bhupen Mehta, IFFCO Kalol

The High Pressure (HP) Synthesis Section consists of Urea Reactor, HP Stripper, HP Carbamate Condenser, and HP Scrubber. All these HP reactors' performance is interdependent which ultimately affects the performance of the Urea Plant. After experiencing oil contamination of the HP Stripper, the plant’s performance suffered. Additionally, the wastewater treatment section experienced operational limitations. This paper will share how both operational bottlenecks were solved by implementing various in-house measures.

Technology innovation driving efficiency improvements in urea production

Toyo’s new urea process “ACES21-LP” provides great benefits to urea plant owners in cost and energy savings

Takahiro Yanagawa, Toyo Engineering Corporation

TOYO’s ACES21® urea process was launched in the late 1990s and has since been multiple references, including two 4,000 t/d urea projects. This paper will introduce their new process, ACES21-LPTM. This new process relaxes urea synthesis conditions to 136bar and 180C, the mildest among modern urea processes, while simultaneously achieving CO_2 conversion at 62+%, the highest among them as well. ACES21-LPTM enables lower emissions and OPEX, owing to a 5-10% reduction in power requirement in the CO_2 compressor, ammonia & carbamate pumps. CAPEX is reduced by relaxed mechanical design conditions for HP synthesis equipment and machineries.

The basic process scheme of current ACES21 is maintained in ACES21-LP, allowing existing plants operating ACES21 to be up-graded to ACES21-LP with minor modifications (no modifications required for HP synthesis equipment and machineries). Upgrading to ACES21-LP reduces overall energy consumptions by 3-5% or increases urea production by 3%, resultantly equivalently less GHG emissions per ton of urea, and the up-grading expense can be recovered within a year.

The paper introduces technical features of ACES21-LP, benefits and significance for urea producers provided by the new urea technology of TOYO, and typical schemes to up-grade existing urea plants to ACES21-LP.

Application of technology features in a large scale urea granulation plant
Simon Koch; Martin Pieper, thyssenkrupp Fertilizer Technology GmbH

This paper will detail the 2022 commissioning of a single train urea granulation plant with a capacity of 3900 MTPD in the Sultanate of Brunei. Several unique features of the UFT® Fluid Bed Granulation Technology are employed, including tkFT´s proprietary Ammonia Convert Technology (ACT); newly developed spray nozzles to increase product quality; and the horizontal low pressure drop scrubbing system.

This presentation will deal with commissioning challenges and their solution and will provide an overview about the achievements with respect to product quality and reduction of environmental impact.

Focus will be given to the product quality for a plant of this capacity operating under tropical conditions, and the environmental sustainability improvements offered by eliminating the ammonium sulfate bleed stream typically coming out of an acidic scrubbing section.

Latest developments and projects in fluidized bed granulation
Ken Monstrey, Green Granulation Ltd/Casale

The fluidized bed technology of Green Granulation features low energy consumption and high efficiency process. The most recent references in Urea and (Calcium) Ammonium Nitrate granulation involve the application of the latest technologies such as high efficiency scrubbing of dust and ammonia and low energy overall consumption per ton of produced granules. New developments involve Formaldehyde Free urea granulation for DEF applications, Urea + Ammonium Sulphate granulation for grades from 0.1 to >25% AS content in the final product and high flexibility. Also under development are granulation processes that allow multi-nutrients and urease inhibitors to be added to the process without impact on the quality features of the product.

This paper will incorporate details from the successful commissioning of the 1000MTPD GU3 unit at Indorama Port Harcourt, Nigeria. In addition, it will detail the joint project between Green Granulation and Casale on a new ammonia and urea project, both licensed by Casale, to be constructed in the city of Yangiyer in the Republic of Uzbekistan, for which Green Granulation intends to license and design the granulation unit. Finally, the paper will highlight the recent acquisition of Green Granulation Limited by Casale SA.

Use of Safurex® thin foils for Pressure, Level and Flow transmiters
Guido Gerts, Stamicarbon

Urea plants often experience maintenance issues that relate to (extended) diaphragm type pressure, level and flow measurements. Many (if not all) problems root cause can be linked to the harsh, corrosive environment in many sections of the operating equipment in a urea plant.

Based on the exceptional carbamate corrosion properties of the proprietary Safurex® material, Stamicarbon, Sandvik and Badotherm have combined efforts to develop a thin Safurex® foil with the right ductility and micro structure. In addition, welding procedures have been developed and certified, including welded test seals that have been extensively tested. This paper will present the complete (body and diaphragm) Safurex® seals of exceptional corrosion resistance and quality.

Superior mechanical reliability of urea plants through post-EPC assistance
Masashi Takahashi; Yoshiro Ideguchi, Toyo Engineering Corp.

This paper will outline the variety of services provided by Toyo to enable the long-term stable operation of urea plants. These include: an advisory service on inspection & repair during shut-down maintenance; stable supply of spare parts including proprietary items; and replacement and/or on-site refurbishment with the latest technology for aged high-pressure equipment.

It will also detail how Toyo is developing real-time corrosion monitoring of high-pressure equipment and piping in the urea synthesis loop, and simulation-based corrosion prediction by utilizing more active data from actual operational condition.

Focus will be given to the development of a successor to DP28WTM, a corrosion-resistant duplex stainless steel. Laboratory testing proving that the new grade DP28WTM has better corrosion resistance compared to the existing DP28WTM will be detailed. Specifically, the corrosion resistance of the heat-affected zone, which could be an unavoidable weak point of all duplex stainless steels, is improved.