

FAI ACTIVITIES

Conference on Fertiliser Technology

FAI organised a Technical Conference on **Improving Productivity and Reliability of Fertiliser Plants** during 23-24 April, 2015 at New Delhi. The Conference was inaugurated by Mr. Satish Chander, Director General, FAI, New Delhi. Mr. Rajesh Aggarwal, Operations Director, Kribhco, Surat, delivered the keynote address. The Conference was attended by 120 delegates from fertiliser plants, technology suppliers, consultants, catalyst suppliers, equipment vendors and research organisations. An exhibition was also arranged where 4 vendors participated.

Inauguration

Mr. Satish Chander, Director General, FAI in his inaugural address commended the efforts of the industry in improving the efficiency of the plant. He expressed concern over the pricing policy of the government which does not provide due incentive for efficiency improvements. He mentioned that reforms in fertiliser sector announced in 2009 but government selectively implemented nutrient based subsidy (NBS) policy for phosphatic (P) and potassic (K) sectors in 2010. The policy has worked well for the P&K sector. FAI has been pursuing with the

government to bring similar reform in the urea sector. He briefed about the proposed new urea policy which was to be implemented on 01.04.2015 on expiration of existing policy but the announcement is delayed. He informed that pooling of gas price will be a part of the proposed urea policy. This would provide the level playing field to all gas based urea units. Existing energy consumption norms are likely to be further tightened. This would offer a direct challenge to the plant personnel, technology suppliers and all involved in production of fertilisers. These norms for individual units will be applicable for first three years and from the fourth year onwards individual norms for energy consumption will be merged into three groups. Therefore, it will be a challenge to urea units to maintain or improve energy efficiency to remain viable.

Mr. Satish Chander briefed about the proposed policy for production of urea beyond reassessed capacity. He further stated that FAI has been representing to the government to allow production from three naphtha based plants till gas is made available to these plants. He mentioned that the industry has to continuously upgrade its technology to meet the stringent

energy, environment and safety regulations. He hoped that deliberations in the Conference would help to meet these objectives.

Earlier, Mr. Rajesh Kumar Aggarwal in his address pointed out the importance of ammonia and urea in solving the food security problem of the country. He mentioned that country is heavily dependent on urea as it provides the maximum output at minimum cost. Natural gas is the feedstock for production of urea for which there is large dependence on import due to shortage of domestic gas. He pointed out that ammonia urea plants having two streams have been revamped to produce 3600- 3700 MTPD ammonia and corresponding 6300-6400 MTPD urea. The space available with the plants has been fully utilised. Emphasising on the continuous operation of the plant, he mentioned that a start-up due to unforeseen shutdown costs Rs. 5 crores considering energy loss of 20000 kcal/SM³ per start-up and cost of energy as Rs. 2500/SM³. He pointed out root cause analysis of trips indicated that these shutdown were avoidable and occurred due to negligence during retrofit or revamp. He advised that the plant should operate in a manner that shutdown to be taken



Mr. Satish Chander, DG-FAI, delivering the inaugural address



Mr. Rajesh Kumar Aggarwal, lighting the lamp during inaugural session along with DG-FAI

only once in two years. He opined that running a plant continuously without breakdown provides better efficiency than producing a few tonnes more.

Sharing the experience of revamps carried out at various plants of RCF, NFL and Kribhco, he appreciated that the technology adopted helped in improving productivity and energy efficiency. He mentioned that number of plants could achieve their revamped capacity as a result of improvement in reliability and selection of technology at the time of revamp. There is a need for technology suppliers and users to select the right type of equipments as very thin margins have been left for safety and each shutdown carries a huge cost.

Earlier Dr. S. Nand, Deputy Director General, FAI welcomed the chief guests and delegates. He mentioned that the technology conference is organised once in four years to update on all developments related to production technology. The other programmes organised by FAI are specialized and focused on one particular area. He expressed that most of the fertiliser plants have reached a level of saturation in terms of on-stream, energy and raw material efficiency. Industry is further exploring the technologies for incremental improvement for old to very old

generation plants. Most of the technology suppliers and vendors are well aware of the status of fertiliser plants in India and bring technology to further improve the efficiency.

Mr. Manish Goswami, Deputy Chief (Technical), FAI thanked DG, FAI for providing the insight of the policy and Mr. R. K. Agarwal for sharing his experience with the delegates. He thanked the fertiliser companies, vendors, sponsors, advertisers for their support.

Session I

The Technical Conference was divided into six sessions spread over two days. The first and second Sessions were devoted to improving the efficiency of ammonia plants. The first Session was chaired by Mr. Rajesh Kumar Aggarwal, Operations Director,

Kribhco. Three papers were presented during the Session viz (i) KBR's Purifier Technology for Improving Reliability of Grass Root Ammonia Plants by Mr. Akhil Nahar, KBR Technology, Gurgaon, (ii) SAVeNG Concept: An integrated Approach to Energy Savings in Ammonia Plants by Mr. Damiano Marzari Chiesa, Casale, Switzerland and (iii) Higher Efficiency and Lower Energy Consumption of Ammonia Plants with Superior Catalysts by Mr. Stefan Gebert, Clariant, Germany.

Mr. Akhil Nahar highlighted the advantages of purifier technology compared to a conventional ammonia process. The ammonia plant capacity of 3500 MTPD could be designed with single horizontal 3-bed converter using purifier technology. Excess air is used in the secondary reformer and use of purifier eliminates the need for purge gas recovery unit. Excess air in secondary reformer also generates about 8-10% more carbon dioxide. The size of primary reformer could be reduced by 30% with mild operation conditions due to shift of duty to secondary reformer. Other features include non-metallic mixing chamber in secondary reformer and unitized chiller in synloop. He also presented experience of operation of ammonia plants with purifier technology, their energy consumption and on stream efficiencies.

To a query on application of KRES and purifier, Mr. Akhil Nahar replied that KRES is added parallel

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to primary reformer to increase capacity by avoiding revamp of primary reformer while purifier is used for purification of synthesis gas. He further informed that the KBR is offering both KRES and Purifier in a standalone ammonia plant where requirement for steam export is not high. To another query on how much energy saving could be achieved in a revamped plant, he mentioned that revamped plant efficiency would depend upon level of efficiency before revamp. However, it would require a huge investment for an old generation plant to match energy efficiency of a new plant because of inherent disadvantages in process integration and equipment. Another query on advantage of availability of more High Pressure (HP) steam generated through two converters in place of one, Mr. Nahar replied that two converters are used to increase the conversion per pass and same objective is achieved by using a 3 bed single converter in KBR process without affecting the advantage of HP steam generation. In reply to a question on experience of revamp of Gas Turbine (GT) as drive for Process Air Compressor (PAC) and utilisation of its exhaust as combustion air for primary reformer burner, he mentioned that this is one of the options for revamp. However, this option is not lucrative for revamp as it requires lot of space and ducting.

Mr. Damiano Marzari Chiesa presented an integrated approach to optimise the steam and power systems to improve the capacity and efficiency of ammonia and urea plants. The revamp options could be applied to ammonia plants from 600 to more than 2000 MTPD and all urea plants irrespective of technology. He informed that energy saving to the tune of 0.5 Gcal/MT of urea could be achieved in a urea plant with capacity of 3100 MTPD. In ammonia plants the modifications involve installation of a radial pre-reformer which optimizes S/C ratio and reduced firing, revamp of CO₂ removal system with GV low

energy system and ammonia wash unit with loop reversal. The modification in machinery would also be required for higher efficiency. The urea plant modifications suggested were optimisation of loop pressure and N/C ratio, maximum recovery of process heat from ammonia preheater and pre-concentrator and change of CO₂ compressor to motor drive.

In response to a query, Mr. Damiano Marzari Chiesa clarified that the energy saving of 0.5 Gcal/MT is for the overall ammonia-urea complex as result of integration of various units in ammonia and urea plants. To another query, he mentioned that for VAM some source of heating and cooling is needed which could be obtained from low pressure steam generated either from process heat recovery or exhaust of gas turbine and is available at no cost. The energy consumed in associated cooling water system would be lesser compared to the compression energy saved in CO₂ Compressor. On question of alternate feedstock, Mr Chiesa informed that Casale had carried out experiment with coal as feedstock but it does not own technology for coal gasification. Casale has only developed process for downstream sections like shift, purification, synthesis, etc.

Mr. Stefan Gebert presented that catalysts have played a major role in improving efficiency in ammonia plants. He presented that Clariant has developed more active ammonia synthesis catalysts, reforming catalysts with low pressure drop and more selective catalyst for LT shift. He informed that the AmoMax-10 catalyst in synthesis converter could increase conversion upto 1% and reduce loop pressure upto 10 bar. The catalyst also reduces the start-up time and hence lesser natural gas consumption. The AmoMax catalyst is based on Wustite instead of Magnetite and have more stabilised Fe and increased surface area. The activation energy requirement is 30% lower

compared to conventional magnetite based catalysts due to lesser oxygen content. He further listed benefits of use of ReforMax Catalysts for primary reformer which could reduce the tube wall temperature, higher hydrogen production and low pressure drop. He presented a case study of 1200 MTPD plant in Western Europe where with the use of ReforMax catalyst the ammonia production increased by about 9 MTPD. Mr. Gebert explained various factors that influence the activity of a catalyst. The size of the catalysts has undergone tremendous improvement and help in reduction of pressure drop. He presented experience of use of AmoMax catalyst in two ammonia plants in China and Russia. He shared experience of ReforMax catalyst in a 2300 MTPD ammonia plant in Australia and another plant revamped from 1675 MTPD to 1890 MTPD in India.

During discussion, Mr. Stefan Gebert informed that to operate S/C ratio of 2.6-2.8, a specialized catalyst is required to avoid soot formation. The soot formation could be avoided temporarily by injecting steam time to time. To a query on reduction of pressure drop in synthesis section on using the AmoMax, he replied that quantum of reduction in loop pressure would depend both on the loop pressure and recycle and would be plant specific. Guarantees could be offered only after studying the plant. On guidelines on maximum duration for steaming the primary reformer in case of shortage of natural gas feed, he replied that temperature at the outlet of primary reformer should be maintained at of 650-700°C for 10-12 hrs depending on the life of catalyst. He replied that for various types of reforming catalysts the surface area is in the range of 8-10 sq.m/gm. He mentioned that the LDP shape of the catalysts with 10 holes and voids help gas to pass through easily and hence less pressure drop compared to a compact particle. In reply to a query on lesser time for reduction of

synthesis catalysts, he mentioned that this is due to lower oxygen content of Wusitie catalyst.

Chairman in his concluding remarks mentioned that the purifier technology is intended for separation of inters from syngas and this is successfully working in both the revamped ammonia plants at Kribhco. However, there is an issue related to higher pressure drop than design and Kribhco is working with technology supplier for the solution. He advised the participants to take an integrated approach while implementing energy saving scheme in fertiliser plants. The ammonia wash unit and VAM in CO₂ compressors have already been implemented by plants in India. On the option of conversion of steam to motor drive, he informed that a study undertaken by Kribhco showed that by converting both the CO₂ compressors to motor drive (7MW each), a saving of 0.13 Gcal/MT could be realised for two urea plants with combined capacity of 6000 MTPD. He appreciated that the catalysts supplied by Clariant for primary reformer could perform with almost same efficiency even after 10 years of operation. Synthesis required shorter time for 1 or 2 days for reduction due to lower oxygen content of Wusitie. He pointed out that fertiliser plants are operating very efficiently and with high reliability despite old vintage. Hence, catalyst suppliers should provide adequate guarantees for faster decision making in purchase of catalyst.

Session II

The Session II was also devoted to Improving Productivity and Reliability of Ammonia Plants and chaired by Mr. A. K. Lahiri, General Manager (In charge), NFL, Vijaipur. Three papers were presented in the Session which included (i) Energy Consumption for Ammonia/Urea Plants: Analysis and Optimization by Dr. Klaus Noelker, Thyssen Krupp, Germany, (ii) Improving Efficiency

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Session II : Dr. S. Nand, Mr. Klaus Noelker, Mr. A.K. Lahiri, Mr. Luigi Tomasi and Mr. M. Venkat Ramesh

of Carbon dioxide Removal System, by Mr. Luigi Tomasi, Giammarco Vetrocoke, Italy and (iii) Lean Duplex SAF2304 a Solution for Heat Exchanger Tubing in Ammonia Condensers and Cooler by Mr. M. Venkat Ramesh, Sandvik Asia Pvt Ltd., Pune.

Dr. Klaus Noelker made analysis of energy consumption for a 3300 MTPD ammonia plants of Udhe. He presented a few scenarios for optimizing energy efficiency in ammonia plants. He compared the optimisation of ammonia plant without steam export to that of ammonia plant with steam export. The plant where no steam is exported potential of energy saving is nil in the feed but some fuel saving is possible by lowering fuel firing in reformer and utilising process waste heat within the process. He suggested that steam should be utilized to maximum within the ammonia plant. Steam export is possible when ammonia plant is integrated with a urea plant. In such cases waste heat should be utilized for generating more steam. Dr. Noelker discussed the advantages and disadvantages of GT as driver for Process Air Compressor (PAC), GT as driver for PAC and generator, GT as driver for large generator (compressor on motor), GT as driver for PAC and use of flue gas as combustion air in reformer. He opined that the GT Drive with PAC is suitable for revamping plants that require replacement of existing PAC. GT

for gear type PAC and power generator are suitable for revamp, if existing PAC requires replacement and there is additional demand for electricity. GT drive for combustion air for primary reformer is not suitable for revamp as it requires complete change of reformer combustion air and flue gas system. He concluded that Gas turbine drives with waste heat utilization can significantly improve the energy efficiency by higher steam export from ammonia plant. Though investment cost is high but payback is very attractive in view of high energy prices.

Mr. Luigi Tomasi, Giammarco Vetrocoke presented the GV low energy process with two stage regeneration operating at 1.0 kg/cm²g and 0.15 kg/cm²g. The differential pressure generates flash steam of lean and semi lean solution flowing from HP to LP strippers. The energy saving from generation of flash steam by pressure difference helps in saving 45% of the regeneration heat requirement. The regeneration heat is required in the range of 600-700 kCal/NM³ CO₂ with CO₂ slip of 500 ppm. He introduced a hybrid concept with integration of chemical and physical absorption systems. A pre-absorber based on physical absorption method was suggested as a standalone unit in an existing plant to absorb 33% of CO₂. The energy consumption with hybrid system can be further reduced to 470 kCal/NM³ CO₂.

In response to a query on reference for hybrid installation, Mr. Tomasi replied that at present it is at conceptual stage, however, it is combination of two well established technologies of physical and chemical absorption. The solvent is a proprietary of MDEA and BASF and the scheme has been patented. To another query, he replied that the existing solution of CO₂ absorption is not required to be replaced. In reply to another query, he mentioned that the size of physical absorption equipment is small hence there is very minimum increase in pressure drop. He mentioned that a CO₂ removal system completely based on physical absorption system is possible however the cost of replacement of existing system and procurement and installation of new system would be very high. The hybrid system is designed for maximum utilisation of existing system and faster integration with new system. In response to another query, he mentioned that overhead condenser is not required to be replaced but booster compressor need upgradation or parallel booster may be considered in some approaches of revamp.

Mr. M. Venkat Ramesh in his presentation described various reasons for corrosion in the synthesis gas coolers, inter stage coolers, ammonia condensers, CO₂ stripper and lean amine solution cooler. He presented the composition of SAF 2306 grade and its mechanical and physical properties. The SAF 2306 showed better tensile strength and hardness compared to conventional materials. The resistance of material to pitting, stress and erosion corrosion was better than conventional materials. Due to dual phase of duplex, inter granular corrosion and trans granular corrosion in austenitic and ferrite phases nullify each other. This makes duplex good SCC resistance specially against chlorides and carbonic acid attack. He informed that the thermal expansion of material is similar to that of carbon steel hence same tubesheet can be retained and

there are no issues with welding with 304 L or 316 L grades tubesheet.

In response to a query, Mr. Ramesh replied that lean duplex was not suitable for sulphuric acid or phosphoric acid plants as for those applications the material should have higher nickel and copper. In sulphuric acid plant, it may work for low concentration and temperature but material should have minimum 30% nickel and copper alloy to give corrosion resistance. To another question on experience with duplex materials, he informed that a number of plants in India (Indo Gulf Fertiliser, Jagdishpur, RCF, Thal, IFFCO, Kalol and SPIC, Tuticorin) have changed over from carbon steel to duplex for ammonia condenser. Replying to another question, he said that the lean duplex material could be made available in all forms, however, Sandvik supplies them in the form of tubes or pipes but other suppliers offer in other forms. On a query about welding electrode, Mr Ramesh mentioned that a special electrode of lean duplex with slightly higher in nickel and nitrogen contents are available for such services.

Mr. A. K. Lahiri, Chairman of the session remarked that ammonia was not envisaged to be used initially for fertiliser production and specifically urea where both raw materials, i.e., NH₃ and CO₂ for making urea are available from same plant. He mentioned that vast developments in ammonia

technology have resulted in significant improvement in energy efficiency and reliability in ammonia production. Improvement in catalysts, reforming at high pressure, integrated heat recovery, GT driven compressor, short loading of catalysts, development in CO₂ removal and synthesis sections, improvement in monitoring of rotating machines and safety systems, etc., have made the production of ammonia more efficient and plant more reliable.

Session III

Mr. M. R. Patel, Senior Executive Director, IFFCO, Kandla chaired the Session III devoted to Improving Productivity and Reliability of Sulphuric Acid Plants. Three papers were presented in the Session on (i) Improving Efficiency and Reliability of Vintage Sulphuric Acid Plants by Mr. T.N.V. Satyanarayana, Technip India Limited, Chennai, (ii) Novel Venadia Catalysts for Low Temperature SO₂ Oxidation by Mr. M.S. Sundaram, Sud Chemie, New Delhi and (iii) Role of Catalysts in improving Efficiency of Sulphuric Acid Plants by Ms. Setu Bajpai, Haldor Topsoe, Faridabad.

Mr. T.N.V. Satyanarayana mentioned that when capacity of equipments is fully utilised during revamp, older plant may face problem of increase in pressure drop during low load operation. Older plants faced problems as



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there are no margins left in air blowers, heat recovery is lower due to fouling and plugging and SO₂ emission is higher. He also touched upon other operational and mechanical problems in old plants. He presented the latest trends in design of new sulphuric acid plant which include overhead melting tank with internal steam coils having more efficiency and lesser space requirement. Both fire tube or water tube boilers are being suggested by technology suppliers. Converter with 3+2 bed configuration and use of casesium catalyst in first bed for lower initiation temperature were suggested for higher conversion and low SO₂ emission. Provisions of utilisation of low grade waste heat for preheating of BFW and production of hot water for concentration section are being offered. The structured tower packing with geometrically arranged corrugated sheets provides uniform gas distribution, resulting in intimate mixing and radial distribution of the liquid and gas streams. He presented the areas of improvement for old plants include sulphur melting/ filtration/ storage system, air system, sulphur furnace, converter, drying / absorption systems, heat recovery systems and start up systems. He brought out the various operation and maintenance issues associated with old generation sulphuric acid plants. He also suggested few measures that could help in reducing emissions from the sulphuric acid plant.

During discussion, Mr. Satyanarayana informed that despite the fact that with HRS system 70-90% heat recovery is possible and cooling tower capacity could be reduced, many plants have not adopted it because of difficulty in locating space for HRS due to duct routing. Secondly, the economics of existing plant do not favour HRS because of non-availability of utilities to effectively utilize additional low heat recovered. To a query, he replied that melting of prill sulphur would take lesser time than pelletized

sulphur. However, he added that melting of prill sulphur gets affected by the purity of sulphur. To another query, he replied that there is no plant operating with 0.5 kg/te SO₂ emission. For removal of sulphur sludge from overhead melting tank, he mentioned that the tank is cylindrical with conical bottom and placed above ground and cleaning can be carried out once a day with the help of plug type valve at the bottom of cone area. Long term cleaning requires complete isolation of the system for removal of harder deposits and is carried out once in six months but frequency would also depend on the purity of sulphur. On use of vapour ammonia for melting sulphur, he replied that it is being practiced in some places but effectiveness is less due to vaporization resulting in low mixing and neutralization. This is not recommended from environmental point of view due to emissions of ammonia vapour to atmosphere. To yet another query on increasing the sulphuric acid plant capacity by use of enriched oxygen, he replied that by increasing oxygen alone would not result in increase in conversion. It would be possible if there is a converter with 3+2 configuration so that additional oxygen is injected between 4th and 5th pass. Mr. Satyanarayana, in response to a query on types of pumps, replied that most of the pumps used in sulphuric acid plants are vertical pumps and MOC depends upon the application, concentration, temperature, etc.

Mr. M.S. Sundaram presented a range of SulfoMax catalyst designed for different requirement of sulphuric acid plant. The newly developed SulfoMax Environmental Version (EV) catalyst works at very low inlet temperature thereby enabling higher conversion and in turn lower stack SO₂ emissions. The catalyst surface has been modified with diatomaceous earth (DE) for higher activity and is promoted with proprietary metal sulphate for low temperature activity. The results of experiment of catalyst at a plant

site were presented which showed marked improvement in conversion efficiency and lower SO₂ emissions.

In response to a query on use of Sulfomax CV catalyst resulting in efficient emission control, Mr. Sundaram replied CV is designed for final pass and has high concentration of Casesium and Vandium. He mentioned that SO₂ conversion after third pass at first stage of pass is around 1-1.5%. He further informed that in one of the plants, change of catalyst to Sulfomax, concentration of SO₂ was found to be <1% and conversion across final pass improved from 94% to 99.5%. To a query on use of enriched oxygen, Mr. Sundaram mentioned that sulphuric acid plants based on metallurgical SO₂ gas utilises oxygen that help in reduction in catalyst volume and size of the plant but it should be considered right from the design stage.

Ms. Setu Bajpai presented the development of sulphuric acid catalysts by Haldor Topsoe. She pointed out that for a standard catalyst with low initiation temperature requirement for catalyst would be high. The Topose VK 69 provides higher conversion with low catalyst volume. She presented that with use of VK 701 in 3rd bed, which is designed for high SO₃ concentration, conversion increases in the 3rd Bed. The conversion further improves if it is used in conjunction with VK 69 in the 4th bed. She also introduced a dust protection catalyst that helps in reduction of pressure drop due to dust deposition in the first bed. Commenting on the need for screening of catalyst, Ms Setu Bajpai recommended that it is not necessary to screen the catalyst in 2nd, 3rd and fourth pass but for the first pass it may be screened after two year only if there is increase in pressure drop. Screening activity could destroy catalyst or may result in ingress of water vapours. To another question, she affirmed that VK701 is a replacement for VK48 if there is requirement for low emission. To another question

on use of VK 69 in fourth bed, she mentioned that it has been designed for lower inlet temperature in the first bed (around 380°C) but it would not provide any benefit in lowering of emission by using in fourth bed. Reference for use of VK701 is not available in India but references in other parts of the world are available. Responding to a query on dust protection catalyst, she clarified that it actively participates in conversion but due to its large size its activity is lower compared to conventional catalyst. The dust reduction catalyst is added above the existing catalyst with a height of about 15 cm. In case of space constraint, part of top layer of old catalysts can also be replaced.

Mr. M. R. Patel informed that IFFCO Paradeep installed first Heat Recovery System (HRS) in India a year back and heat rejection in cooling tower was reduced significantly. However, many plants in India have not adopted HRS. This may be due to several reasons including space constraints.

Session IV

The Session IV on Improving Efficiency and Reliability of Urea Plants was chaired by Mr. M Sagar Methews, Director (Technical), NFL Noida. Three papers were presented in the Session viz, (i) Evolve- CO₂ Production Add-on for Urea Revamping Consuming Excess Ammonia into Urea by Independent CO₂ Production by Ms Barbara Cucchiella, Stamicarbon, The Netherlands (ii) Vortex Granulation: Flexible Tool for Boosting Finishing Section Performances by Ms. Serena Gabbiadini, Casale Switzerland and (iii) Improving the Efficiency of Urea Prilling Tower of Existing Plants with JSC NIIK Technology by Mr. Alexey Andreev, JSC, NIIK Russia.

Ms. Barbara Cucchiella introduced the Stamicarbon's CO₂ production technology to utilize the excess ammonia to produce

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additional urea. She presented the limitations of post combustion flue gas capture method where CO₂ partial pressure and concentration are low and require active solvent with higher reaction energies and thus higher regeneration energy. The flue gases are present at high temperature and have NO_x and SO_x contaminants. She presented the Stamicarbon technology based on the Catalytic Partial Oxidation (CPO) of natural gas, to convert hydrocarbon in presence of air and steam into syngas. The syngas produced over the catalyst is composed of a mixture of H₂, CO, CO₂, unreacted CH₄, unreacted H₂O and N₂ which are then sent to water gas shift reactor. The CO₂ production unit works in parallel to the syngas production and does alter the existing plant configuration. The feedstock is obtained from hydro-desulphurization section and extra CO₂ is sent to the urea plant. The H₂ rich fuel gas substitutes the part of natural gas burned in the steam boilers or steam reformer heater. CO₂ is extracted from process gas by the chemical absorption with amine system identical to that installed in the conventional ammonia section. She compared the production cost (capital, operating and maintenance) of the CO₂ production technology at various gas prices. She concluded that the

technology offers an economic option for higher urea production compared to conventional flue gas recovery process at gas cost of 4.77 \$/mmbtu.

To a query on effect of sulphur dioxide on downstream process steps, Ms Barbara Cucchiella replied that the natural gas is routed through desulphurisation and other contaminants like nitrogen and methane are recovered in recycle loop and sent along with hydrogen to be used as fuel in auxiliary boilers or reformer. Responding to another query, she mentioned that the CO₂ generated is sufficient to produce 100 MT urea. On comparison between Evolve process with post combustion recovery, she mentioned that while the recovery of flue gas is greener process but Evolve is more economical considering the Capex. To yet another query, she replied that Evolve is a self-sustaining process and has not been designed for export of LP steam, however, since the process is exothermic, there is a possibility to recover the waste heat.

Ms. Serena Gabiadini presented the vortex granulation for the debottlenecking of the existing prill tower as well as for new urea plant. It can be designed for any capacity and could be installed

within annual turnaround. She mentioned that the Vortex granulation unit works in parallel with the prill tower. The core of the Vortex granulation is a rotating fluid bed in which the rotating motion of the particles obtained is similar to the motion obtained in drum granulators which allows a better control of spraying. The urea melt is sprayed into the rotating fluid from side which provides uniform growth of the granule and the final product has a size distribution equal or better than the seeds. Melt urea is sprayed into the fluid bed using spraying nozzles which produce small droplets or a thin film of urea melt over seeds. She underlined advantages of the Vortex granulation as simple plant operation, short start-ups, lower maintenance costs, lower operating cost, uniform product distribution, etc.

Ms. Serena Gabbiadini during the discussion informed that the number of nozzles of vortex granulation depends on the urea solution required to be sprayed and maximum 350-400 kg/hr solution can be sprayed. Further, she clarified that change in weather does not affect granulation as only the feed prill temperature is changed due to weather while air fed to granulator is heated inside the granulator. Responding to a question, she mentioned that the length of granulator is about 18-20 meters and maximum capacity of one section can be 600 MTPD of sprayed product. The frequency of cleaning of granulator is 40-45 days and operation and maintenance takes about 8 hours. Referring to another query, she informed that energy consumption for vortex granulation system would be 20 kW/tonne urea. Small amount of steam is used for heating of air and fluidization. Regarding location of the granulator, she mentioned that due to requirement of huge amount of fluidization air at low density and ducting requirement, it is preferred to be located at the ground floor.

Mr. Alexey Andreev in his presentation highlighted the concepts developed by NIIK for revamping of conventional prill towers. This included replacement of bucket for urea melt spraying with a vibro-priller, installation of a fluidized bed cooler and installation of wet type dust traps for air treatment. He presented that vibropriller improves granulometric composition of urea prill. The regular vibrations of vibroprills help to divide the melt jet through hole arranged at various angles such that uniform distribution of prills into equal size takes place. This results in lower product temperature and maximum utilization of the tower volume. He suggested installation of a fluidized bed cooler for increasing the intensity of heat exchange process for reduction of temperature (around 50° C) of the prills at the outlet of the unit. He also introduced a purification unit consist of injection scrubber and dust trap to reduce urea dust emission. The purification unit ensures efficient heat and mass exchange between gases and liquid media providing high purification rate. In this scrubbing method, the equipment can be fitted into the existing design of prilling unit. He presented case studies of implementation of NIIK technologies for modernization of prill towers which are running successfully. NIIK's experience can be used for revamps of prill towers not only for urea plants but also for ammonium nitrate and complex fertiliser plants.

Mr. Alexey Andreev in response to a query, mentioned that the improvement in prill strength by use of vibropriller is possible due to enlargement and uniform distribution of prills. To another question, he replied that the cleaning frequency of vibropriller is once a year during annual shutdown. To yet another query, he replied that rotating vibropriller is more useful to improve the product quality than static vibropriller.

Mr. M. Sagar Methews, Chairman of the Session expressed that improving productivity and reliability of plants is important as the industry is passing through a difficult time due to many uncertainties. The industry would remain viable by implementing schemes to improve productivity and reducing specific energy consumption. The urea process has evolved from once through process to total recycle based on carbon dioxide or ammonia stripping technology. He pointed out that the presentations made in the Session were related to each other. NIIK presented technology for improving efficiency of prill tower while Casale offered an option for granulating additional urea in case of limitation in prill tower. Stamicarbon offered a solution to increase the carbon dioxide production provided the cost of natural gas is favourable.

Session V

The Session V on Improving Productivity & Reliability of Phosphoric Acid & Complex Fertiliser Plants was chaired by Mr. G. M. Patel, Technical Director, CIFC, New Delhi. Three papers were presented in the Session viz, (i) Role of additives in Improving Extraction Efficiency in Phosphoric Acid Manufacture by Mr. G. M. Patel, Technical Director, CIFC New Delhi, (ii) Optimizing Operations of Complex Fertilizer Plants through Behavioural Practices by Mr. Narendran Subramaniam, Renoir Consulting Chennai and (iii) Optimizing Operations at FACT Fertilizer Complex by Mr. K. B. Biju, FACT Ltd., Cochin.

Mr. G. M. Patel gave detailed presentation on additives used for foaming, flocculation & scaling problems faced during the manufacturing of phosphoric acid. He presented that quality of rock phosphate plays a major role in extraction efficiency of phosphoric acid production. Three types of additives are used to overcome these problems viz. Defoamer, Flocculant and Antiscalant. Foaming results due to release of

Conference on Fertiliser Technology Productivity and Reliability of Fertiliser

23 - 24 April, 2015, New Delhi



Session V : Dr. S. Nand, Mr. Narendran Subramaniam, Mr. G.M. Patel, Mr. K.B. Biju and Mr. N. Ramakrishnan

large volumes of carbon dioxide and silicon tetra-fluoride gases that gets entrained in the gypsum slurry. Defoamers are commonly used to control surface foaming and reduce the entrainment of gas bubbles beneath the reactor surface. He suggested that for superior defoaming, the defoamer should be stable in nature and dosage should be 0.05-0.15%. In flocculation phenomenon polymeric materials form bridges between individual particles. Flocculants carry active groups with a charge which counterbalance the charge of the particles. It helps in improvement of gypsum crystallization and hence filtration. He recommended that flocculants should be used in diluted solution as high concentration leads to high viscosity.

He pointed out that scaling is the most common problem faced in phosphoric acid evaporators. The scale deposits can cause a number of operational problems such as plugging of equipment, inefficient feed rate to the evaporators, increased utility costs, lost production due to downtime, and downgraded products from lower concentration due to poor heat transfer. He pointed out that different phosphoric acid plants experience different types of scale, and even within one plant, the type of scale can differ greatly from one location of the process to the other. Certain formulated, water-soluble, functional organic reagents are useful in preventing multiple

species of scale formation in production equipment at various stages of the wet-process for phosphoric acid production. Such formulated reagents extend the continuous operation time by reducing the frequency of the washing/shut down time to remove scale, thereby improving the overall productivity of the equipment and plant.

Mr G.M. Patel in reply to a query mentioned that quantity of addition of silica and kaoline has to be optimised based on the quality of rock which is mainly guided by Fluorine to Silica ratio and should be maintained around 0.9. He gave an example of a plant where 30-40 kg silica /tonne of rock is being added. To another query on system of blending of rock phosphate supplier, he replied that blending of rock is a simple system where two conveyer belts carrying different rock phosphates delivered to a single conveyer for mixing before grinding. A number of suppliers are available who could design the system. However, he cautioned that operation of damper and ratio of various rocks to the grinder is important in order to maintain the uniform quality of rock. In response to yet another query, he clarified that Triple Super Phosphate (TSP) can be produced by using normal phosphoric acid as well as merchant grade. Importing merchant grade acid is more economical. Most of the plants in India are based on dihydrate route and produce acid of concentration varying from 40-

48%, which can further be concentrated to merchant grade. He gave examples of GSFC and FACT where filter grade acid of concentration 26-28% are being used to produce APS having 20% P_2O_5 content. He pointed out that water balance is the limiting factor in operation of phosphoric acid plant.

Mr. Narendran Subramaniam presented results of case studies carried out in various complex fertiliser plants to improve operating efficiency through behavioural practices. He explained that objectives of the programme were to improve the capacity utilization, reduce operational and maintenance downtime, improve management of spares, operational efficiencies like P_2O_5 recovery efficiency in phosphoric acid plant, reduction in P_2O_5 and NH_3 consumption in DAP plant, etc. He outlined the approach adopted to implement various management systems. The causes of problems were identified with the help of plant personnel and various operational accounting and standard operating procedures were redesigned. Communication among the planning, maintenance and production department was one of the key problems identified which was due to lack of adequate data or inability to analyze data properly. Resolving these issues resulted in reduction in downtime, increase in production, improvement in product quality and reduction in stack losses.

Mr. Subramaniam to a query on the difference in ISO and behavioural system replied that ISO is in place in most of the organizations but it is how that is implemented determines its benefit. Behavioural analysis and management are the key elements for success. He clarified that the benefits in his papers were calculated by considering factors jointly agreed with the plant management.

Mr. K B Biju presented the efforts made by FACT for optimizing the

operations of its complex fertilizer and phosphoric acid plants. The efforts were focused on minimizing reactant losses, optimizing consumption ratio, increasing the plant running time, reducing the maintenance needs, minimizing variations in product quality and reducing start-up and shut down durations. FACT at its two manufacturing divisions produce 6.335 Lakh MT of NP (20:20:0:13) and 2.25 Lakh MT of Ammonium Sulphate. The processes in the FACT plants are based on slurry granulation with ammonia, sulphuric acid, and phosphoric acid as raw materials. He presented that for NP (20:20:0:13) production, the mole ratio of ammonia to phosphoric acid is being maintained at 1.4 in reactor and 1.8 in granulator to ensure product quality as per FCO norms. He also presented the impact of impurities of phosphoric acid like MgO, Al₂O₃, Na₂O, CaO on density and viscosity of acid and hence granulation process. The specific gravity of slurry in scrubber and reactor are being maintained to control the water balance. The ammonia losses are being minimized by controlling the fume scrubber liquor specific gravity between 1.19-1.20 and mole ratio at 0.9. He also explained the role of materials of construction for production of phosphoric acid. He mentioned that FACT has shifted to Distributed Control System (DCS) operations to enhance the optimization of process with enhanced safety features. He presented various modifications carried out in the plant such as addition of phosphoric acid directly into the scrubber, use of venture-cyclone scrubbers, etc.

During the discussion Mr. Biju informed that FACT is producing Zincated Factomphos in small quantities. Responding to a question, he mentioned that by maintaining mole ratio of 1.4 at granulator, the reaction is smooth because system is less dilute but fuel consumption will be higher. It provides better control with respect to nitrogen as required N

is maintained without addition of urea. To another query, he replied that addition of ammonia in liquid or vapour form would depend on design of the plant. In case of change from vapour to liquid ammonia, the material of granulator and lining may get damaged. On the question of auto-reversal, he replied that at FACT auto-reversal of granulator is done for LT motor but for HT motor it has to be consulted with electrical engineers. He further informed that auto reversal is being done manually per shift but in case of PLC this is simpler and can be done automatically. To another query on blending of rock, he replied that for blending it is important to identify the limiting factor and in case of FACT it is chloride content. Therefore, only 10% of low grade rock could be blended with higher grade to maintain chloride at a level of 350 ppm. He replied that best operation of exhaust system requires keeping the internal of cyclones free from blocking by regular cleaning. Specific gravity of scrubber liquor has be maintained for high scrubbing efficiency.

Session VI

The Session VI on Improving reliability of Rotating and Static Equipments was chaired by Mr. S. Jaggia, Ex-Operation Director, Kribhco, Noida. Three papers were presented in the Session viz, (i) Revamp Experience of Steam Turbine of Syn Gas Compressor by Mr. Rakesh Markan, NFL, Nangal,

(ii) Revamp of CO₂ Compressors of Urea Plant at NFL Vijaipur by Mr. S. K. Sharma, NFL, Vijaipur and (iii) Improving Life Expectancy of Physical Assets in Fertilizer Plants by providing the Proper Painting Systems by Mr. K.K. Arora and Mr. Mudit Agarwal, Mohan Paints, Lucknow.

Mr. Rakesh Markan gave presentation on the experience of revamp of steam turbine of synthesis gas compressor. He presented that the total job was planned to be completed in 27 days but it took 67 days. The major reasons for delay were numerous jobs that came up during revamp which were otherwise not anticipated. These included modification of seating areas of both front and rear end bearing pedestals, replacement of steam control valve assembly with modified one, machining of 'L' ring seating area in top casing, replacement of all old studs, etc. He advised that to avoid such delays, it should be ensured that there should be availability of spares, special and standard tools, facilities for various machining jobs to be identified well in advance, all machining jobs required to be done to be listed and procedures to be framed. He emphasized that there should be pre-revamp meetings between core team carrying out the revamp project from customer side as well as the OEM side.

Mr. Rakesh Markan on question of prior checking of drawing and



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dimensions of critical spares, replied that in this particular case the time left between annual turnaround and arrival of parts was short and there was a condition that all boxes to be opened in presence of OEM only. He, however, acknowledged that specifications could have been checked from the old spares removed from the machine which are generally kept for emergencies. To another query on maintaining the inventory of critical spares, he agreed that one set of critical insurance spares like rotor, guide blades, etc., have to kept. In this particular case it was deferred till performance of modified spares were proven. In response to yet another query on variation in the diameter of rotor provided by OEM, he mentioned that probable reason could be upgradation of parts by OEM to improve the strength.

Mr. S. K. Sharma presented the experience of revamp of CO₂ compressors and its drive turbine for enhancement of urea capacity from 2620 MTPD to 3231 MTPD. Major modifications were done in the machine to achieve post-revamp duty such as replacement of diaphragm and rotor of LP and HP compressors, modification of HP nozzle and HP valve yoke assembly of steam turbine and replacement of gear box, coupling and intercoolers. He mentioned that modifications along with some specialized machining jobs related to turbine HP valve yoke assembly on turbine casing and rectification

jobs on counter casing of BCL compressor were successfully done within 21 days.

Mr. S. K. Sharma during discussion informed that the radial vibrations after revamp were well within limit and till date no problem was faced in mechanical parts of turbine. To a query on steam efficiency, he replied that since the KW rating was increased and hence number of nozzles and flow rate across the turbine were also increased but efficiency remained same with respect to change in KW.

Mr. Mudit Agarwal presented the customized painting system to overcome problems faced in specific areas exposed to corrosion in ammonia, urea, acids and complex fertiliser plants and associated utilities. He presented that the causes of corrosion in fertiliser plants are atmospheric contaminants, acids, chlorine, ammonia, moisture, temperature and continuous deposition of chemical substances for a long time period on structure and other surfaces. He presented various products for areas of plants like prill tower, silos, conveyors, urea bagging plant, cooling towers, etc. He mentioned the procedure and importance of preparation of surface before painting. He suggested that for good performance steel surface should be sand blasted before commencing the painting. Area exposed to sunlight should be painted with UV resistant paints. Cooling towers should be painted with coal tar epoxy paints. Application of paint should be done at ambient

temperature. He also highlighted the limitations in painting of some of the equipments and civil structure. He mentioned that for keeping the plant clean and corrosion free regular inspection and touch up are very important.

Mr Mudit Aggarwal to a query on life of painting on internal of prill tower replied that it could be 3-3.5 years provided about 25 days of shutdown time is available for preparation of the surface. To another query, he replied that for naphtha storage tank it is recommended to have cathodic protection with zinc silicate primer with 85-90% zinc and solvent free epoxy system in paste form for total DFT of 500 micron to be done in 2-3 coat system. To another query on sulphuric acid tank, he replied that the paint developed by their company has been applied on the exterior areas near sulphuric acid plant. He further informed that they have developed paint solution for internal surface also but it is yet to be commercialized.

The Chairman of the session, Mr. S. Jaggia expressed concern over the bad experience of NFL, Nangal while revamping of syngas compressor. He underlined the importance of meeting with OEMs and suggested to discuss very minute details. He shared the experience of Kribhco where both the turbines of syngas as well as CO₂ compressors were revamped. The capacity increase at Kribhco was about 20%, while in case of NFL it was 6-9%. He informed that Kribhco engaged the technology supplier to OEM for revamp who agreed on the condition that they would open one of the turbines during a shutdown prior to revamp to trace drawing. The technology supplier was not confident of drawings of OEM as the equipment was not delivered by them. Kribhco engineers even identified the workshop prior to job and visited the facilities. For one of the turbines on site machining was carried out to cut down on time.

Emphasizing on the importance of

avoiding forced shutdown, Mr. Jaggia expressed that one shutdown besides loss of production also results in shocks to catalyst and thermal shock to static equipment which increase the cost of shutdown. It is therefore very important to have preventive maintenance and save plant from unnecessary shutdown. He referred to a presentation where it was presented that ammonia plants in the world are operating for more than 1000 days and advised that Indian plant operator should learn to improve their on stream efficiency.

Two brief presentations were made by representatives of M/s Forbes Marshall and M/s Kirloskar pump. Mr. Sanjay Kumar Forbes Marshall presented the vibration and condition monitoring solutions for fertiliser plants. Mr. Madhuttam Kulkarni presented features of various turbine and pumps developed by Kirloskar Pumps.

Conclusion

In the concluding Session, Dr. S. Nand summarized the two day proceedings. He mentioned that Mr. Satish Chander briefed about the recent developments in policies for fertiliser sector. Mr. Rajesh Kumar Aggarwal emphasized that manner of implementation of scheme is more important than technology and operating plants for higher stream days gives better efficiency than producing more.

Dr. S. Nand pointed out that the purifier process offered by KBR and GT driven Process Air Compressor are already well established and number of references are available. Casale presented options such as axial radial prereformer, change from turbine drive to motor drive and ammonia wash unit and lower energy CO₂ removal system with saving potential in the range of 0.4-1.0 Gcal/MT urea. One of the options of turbine drive to motor drive is being explored by IFFCO in their upcoming revamp. The reforming catalysts can have life more than 6 years and operates at S/C ratio of 2.6 and it has been well established that

Wusite based AmoMax10 synthesis catalyst with lower oxygen content compared to magnetite results in shorter reduction time. ThyssenKrupp presented concepts of combination of GT to optimize the overall steam and power balance in ammonia and urea complex. He pointed out that GV offered a pre-absorber based on physical solvent and compared it with GV low energy process. However, it would be interesting to have comparison with other processes such as MDEA which are offering similar energy consumption. The choice of use of better metallurgy for tubing of heat exchangers like ammonia condensers and coolers was offered by Sandvik. The change of MOC of these heat exchangers depends on economics and problems with existing MOCs.

The sulphuric acid plants are quite old and there is scope for improvement right from sulphur melting to absorption (converter, drying, heat recovery). He mentioned that catalysts have undergone tremendous improvement as presented by Sud Chemie and Haldor Topse with specialized promoters for improved conversion. With reference to SO₂ from sulphuric acid plant, he advised the technology suppliers to make claims what can be achieved in practice.

Dr. Nand mentioned that the presentation by Stamicarbon provided an alternative to produce more carbon dioxide. In his opinion it was like adding a parallel secondary reformer which is also a catalytic oxidation and exits of both these meet at the inlet of shift reactor. He mentioned that at present the option is not viable both due to higher cost and limited availability of natural gas. He found options offered by Casale on vortex granulation and NIIK of Vibropriller interesting to increase the capacity of existing urea plants as well as prill quality. Most of the plants have revamped their capacities from 2620 to 3200 MTPD. The plants are able to meet the quality requirement but there may be associated problems like dust generation. Vortex granulation offered options either by further

coating of prill with fresh urea solution or use fines after screening as seed. He mentioned that the second option would provide higher strength to the product. The option presented by NIIK of fluidized bed cooler is well known and implementation of vibropriller to improve the prill quality needs to be explored.

Dr. Nand expressed that Mr. G. M. Patel with his long experience provided the theoretical and practical background of operation of phosphoric acid plants. He pointed out that it is important to have better crystallization at reaction stage itself to have better filtration. This also determines P₂O₅ recovery efficiency and throughput of the plant. The case study by FACT presented the measures for improving productivity of NP granulation and product quality. He further mentioned that in the last session two case studies of revamp compressors were presented by NFL, Nangal and NFL Vijaipur. He informed that FAI organizes a programme for senior maintenance engineers where about 15-20 similar case studies are presented. Such case studies help to draw useful lessons for all plant operators.

In his concluding remarks, Mr. S. Jaggia pointed out that for revamp of plants, there could not be a generalized solution and each plant has to be evaluated individually. Revamping options will depend on status of the plant and targeted results. He mentioned that plant personnels are in best position to carry out such study and outside agencies can only polish them by providing solution which are of proprietary nature.

At the end, Dr. Nand thanked all the Chairmen of the Sessions viz. Mr. Rajesh Kumar Aggarwal, Mr. M Sagar Methews, Mr. A. K. Lahiri, Mr. M.R. Patel, Mr. G. M. Patel and Mr. S. Jaggia for providing valuable inputs and advice. He thanked all the speakers, vendors, exhibitors and participants for their active participation in the Conference.