Frank Notes

Reliability and Efficiency Improvement in Fertilizer Plants

Fertilizer production involves employment of very sophisticated technologies and processing, handling and storage of hazardous chemicals like sulphur, ammonia, sulphuric acid, nitric acid, phosphoric acid and other hazardous chemicals. Plants also operate under extreme condition of temperature and pressure. Any breakdown of the plant can lead to heavy losses on account of energy and production. Reliability of plant and machinery is very important for continuous operation, efficiency and safety of the plants. This assume more significance in view that vintage of most of the urea and complex fertilizer plants is in the range of 20 to 50 years with exception of 6 urea plants commissioned during 2019 to 2022. Being energy and capital intensive, efficient and reliable operation also play a key role in ensuring viability of the plants.

Ammonia is the key intermediate for production of nitrogenous fertilizers. The ammonia production processes involve reactions that are both endothermic and exothermic in nature. Efficiency of the process depends upon utilization of the endothermic heat supplied by burning of fossil fuels and waste heat from flue gases and exothermic reactions. Ammonia plants are effectively utilizing these heat to generate either steam or preheat process gas or air. Older heat exchangers have been replaced with improved designed heat exchangers for higher heat transfer and waste heat recovery. The low level heat which was earlier wasted in cooling water is used in vapour absorption machines (VAM) to cool the process gas for compression thus increasing its efficiency and also the capacity due to higher mass flow. A number of plants have implemented this scheme in process air, carbon dioxide and synthesis gas compressors. Ammonia plants were revamped for higher conversion by incorporating additional converter. Further, efficiency has been improved by revamping the compressors, turbines or replacing them with more efficient ones.

Urea plants have been modified to improve the conversion efficiency of reactor by installing additional trays or replacing old trays with improved designed ones. A few plants have installed a vortex mixer in the reactor to increase the conversion efficiency and reduce steam consumption. Urea plants have been revamped with additional stages such as pre-decomposer and pre-concentrator for higher raw materials recovery and savings in steam. There have been efforts to improve the quality of fertilizer products. Plants have installed acoustic system, vibro-priller or specially designed prill buckets to improve the quality of the prills as well as reduce dust emissions.

Corrosion is one of the critical factors affecting the reliability of equipment in urea plant due to handling of corrosive materials such as ammonium carbamate an intermediate compound produced during production of urea. Precautions such as maintaining passivation air and use of special materials for rectors, strippers, decomposers, pipelines, etc. which come in contact with carbamate solution susceptible to corrosion are being undertaken. Repair and maintenance procedures and workmanship are critical for ensuring reliability of these equipment. Online leak detection system for reactors are available by some technology providers. Use of such a system during operation may help in attending to the very small defects before it become severe and affect reliability of the plant. There have been developments in materials of construction (MOC) of stripper such as bimetallic or proprietary materials that offer better corrosion resistance. Life of the existing strippers were improved by reversal of stripper after a few years of operation and shortening of stripper and save capital investment in a new equipment.

Production of NP/NPK complex fertilizers involves reactions of sulphuric acid with rock phosphate to produce phosphoric acid and then reaction of ammonia with phosphoric acid to produce complex fertilizers. Due to acidic nature

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of materials handled, these plants are also prone to corrosion and erosion of material. The equipment needing special attention in sulphuric acid plant are reactor, intermediate and final absorption and drying towers. The critical equipment in phosphoric acid plant are digester, flash cooler, recycle acid tank, scrubber and vacuum cooler. These equipment are lined with special and rubber materials to improve the corrosion resistance. Complex fertilizers have optimized the process for various grades of products and to withstand corrosive environment changing to improved MOCs for equipment and maintenance practices to achieve higher productivity. As result of aging, timely replacement of a vessel/ equipment is important for safe and reliable operation of the plant. Further, revamping of civil structures to improve longevity of the plants are being carried out. In sulphuric acid plants, operational challenges have been overcome by improving conversion efficiency and improvement in the waste heat recovery. Complex fertilizer plants are highly dependent on imported raw materials and intermediates for production. Raw materials account for major part of cost of production. Therefore, improvement in raw material use efficiency is of utmost importance. For improving the operational efficiency, the efforts have been made to improve the recovery efficiency of ammonia and phosphoric acid. These plants have undertaken modifications in granulator and pipe reactor systems for precise control of grade formulation. Modified design of scrubbing system have resulted in reduced ammonia and particulate matter losses from stack besides providing operational flexibility to the plant.

Technological advancement in the field of instrumentation and control has made plant operation more reliable and safe. There has been upgradation in the instrumentation system from PLC-based to DCS-based system. Use of advance process control further help in optimization of the parameters and smooth operation of the plant. Technologies like artificial intelligence and machine learning are now being adopted to predict the problems in advance. Electrical systems are also made more reliable by improving the power factor, transformer, other electrical systems and grid synchronization.

These efforts have been resulting in significant improvement in efficiency and reliability of the plants. FAI is monitoring vital parameters of efficiency and environment for the last several years. Efforts of the industry are reflected in very significant improvement in performance of all fertilizer plants. The energy consumption for the ammonia plants has been reduced from 12.48 Gcal MT^{-1} in 1987-88 to 8.07 Gcal MT^{-1} ammonia in 2022-23 and for urea plants from 8.87 to 5.71 Gcal MT^{-1} during the same period. In case of complex fertilizer plants, the raw material efficiency of Nitrogen and P_2O_5 also increased from the level of 93% during 1992-93 to the level of 98% at present. The water consumption of ammonia and urea plants has been reduced by about 50% while complex fertilizer plants were able to reduce water consumption by 60% over last 26 years. The waste water discharge has been drastically brought down during the same period. The survey report for downtime shows that forced shutdown due to equipment problems in ammonia plants reduced from average of 24.4 downtime in days per plant per year (DDPY) in 1987-1990 to 6.1 DDPY in 2020-23 period. The urea plants also reduced forced shutdown due to equipment problems from 11.8 DDPY to 6.1 DDPY during the corresponding period.

There was continuous employment of new technologies, timely replacement of old and inefficient equipment, adoption of high degree of automation, better maintenance practices leading to improved efficiency, reliability, safety, and environmental performance of the plants. This Technology Special June 2024 issue highlights the efforts of the industry and it is hoped that readers will find this issue pertinent and useful. ■