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# Reliability of Power and Electrical System in Fertilizer Plants

Fertilizer production is a highly energy-intensive process and fertilizer plants operate continuously year around. Continuous upgradation of technology and equipment, and adoption of improved and maintenance practices have ensured the operation of these plants all year around. Availability of quality power and reliability of electricity systems also play important role in ensuring that there is no forced shutdown of a fertilizer plant on this account.

In the initial phase of development of the fertilizer industry, fertilizer plants relied mainly on the state electricity grids for power supply. Frequent interruption in the power supply as well as fluctuation in the voltage and frequency adversely affected the operation of these plants. It was reflected in low on-stream factor and poor capacity utilization of the plants. The plants which were planned in late 1970s and early 1980s incorporated captive power plants as part of the projects. A number of old plants also added captive power generation facilities.

Gas-based plants installed gas turbine generators (GTG) with co-generation of steam from waste heat. This gave higher thermal efficiency in terms of power and steam generation than the conventional option of steam turbine generators. Gas turbines also proved to be very reliable in ensuring quality power supply all year around. Older generation ammonia and urea manufacturing plants were based on electric motor-driven machines with power requirement as high as 30 per cent of the total energy consumption. The captive power generation was based on coal. To improve the energy efficiency, one of the options is to change from coal-based power generation to gas turbines with heat recovery system. Three such plants are currently in the process of replacing the existing coal-based power plants to gas turbine generators with heat recovery steam generation system.

Over the years, a number of plants undertook revamp to increase their capacity and efficiency. The power-driven machines, such as small motors and compressors, have proven to be more efficient than the steam turbine drive. During revamp, a number of ammonia and urea plants have converted steam-driven cooling towers and other smaller pumps to motor drive. Some complex fertilizer plants added additional stream to increase their capacity and manufacture new products. As a result, the power requirement was increased. The capacity of gas turbine generators was increased by installing inlet chilling system such as vapour absorption refrigeration (VAR). The low-grade heat was effectively utilized in VAR systems. Cooling of gas fuel increased the mass flow and hence the capacity of gas turbine generators. This also improved the energy efficiency of plants. The upgradation was also carried out in the transmission system to take care of higher load from a captive power plant or grid. A number of plants have replaced old motors with more efficient motors for power saving. The efficiency of electrical motors has been optimized by using variable frequency drives which adjust the frequency and voltage depending upon the load and thus save power.

Apart from the captive power generation, fertilizer plants are also connected to grid to meet some part of their power requirements and to ensure the operation of critical machines in case of failure of the captive power plant. Hence, captive power plants are synchronized with the grid power. In such cases, synchronization of captive generation with grid is important. There was an incident that caused the breakdown of a captive turbo generator due to mis-synchronization in the frequency and voltage. This was due to procedural fault as synchronization was in the manual mode and resulted in the damage of stator winding. Precaution should be taken to avoid such incidents. Emergency diesel generation sets are also used by plants in case of emergencies.

**Lessons learnt from the incidents and implementing preventive measures enhance the reliability of electrical system and avoid forced shutdowns and resultant downtime of fertilizer plants.**

For critical loads, uninterrupted power supply (UPS) is used which protects against power disturbances and outages. The maintenance of UPS components, such as rectifier, battery, inverter and static, is necessary to have a reliable power supply when needed. In some plants, power load for lighting and building is also being met through the solar power or other renewable resources.

Another important aspect of the electrical system is the power distribution and control system. The cables and transformers play important roles in the electricity supply to the consumers. Proper functioning of transformers is important to ensure the quality of power and to minimize transmission losses. Cable is an important element of transmission. Periodic monitoring of cable should be carried out to assess its condition as it is important in view of the increased load after debottlenecking. Non-destructive techniques such as thermography and ultra sound technology are available to monitor the condition of electrical cables.

Automation of power plant such as load management system can effectively control the changing demand of power on a real time basis. Such tools are necessary for reliable and safe operation of the electrical devices. Equipment suppliers have developed their own control systems for reliable and safe operation of gas turbo generators and boilers, with some of them offering diagnostic features. A motor control system is also available to control all motors from one location. Old conventional panels have been replaced with distributed control system (DCS), which has increased operational convenience, reduced hand-wiring cables of the motor control centre (MCC) panel and made the circuit simpler.

Other components of electrical systems, such as, electronic relays, switch fuse unit, circuit breaker, soft starters, switchgear units and lightening are also important for reliable operation. The efficiency of a power generation system can also be enhanced by improving the efficiency from demand side. Other measures implemented by plants to improve the reliability of electrical systems include replacement of electromechanical protection relays with microprocessor-based numerical protection relays, replacement of transformers with higher efficiency transformers, retrofitting of oil circuit breakers with SF6 gas and vacuum circuit breakers, replacement of voltage switchboard with higher short-circuit current withstand capacity switchboards and replacement of low voltage switchboards.

Maintenance of entire electrical system is also very important to ensure the overall reliability of plant operation. The Fertiliser Association of India (FAI) has been carrying out the analysis of downtime in ammonia and urea plants after every three years period since 1980s. The latest survey for the 2014-17 period showed that the downtime due to electrical problems was only around 5% of the total downtime in all plants. There were instances when some plants had to take forced shutdown of the complete plant due to electrical faults. Common electrical problems noticed were short circuit in the incoming feeder line, electric bus bar failure, power dip caused by electrical flash in junction box, tripping of pump on earth fault, switchgear house battery charger rectifier problem, current relay malfunction, interruption of UPS power supply to GTG and heat recovery unit (HRU) and subsequently tripping of HRU on low steam drum level. The survey identified areas that need attention in the electrical system. Proper sealing of main receiving substation with respect to dust, and proper cleaning of insulation also need to be ensured. Measures need to be undertaken to avoid over current and earthing faults. The learning from such incidents and implementing preventive measures will enhance the reliability of electrical system and avoid forced shutdowns and resultant downtime of fertilizer plants.

The importance of power supply and electrical system cannot be undermined in continuous process plants. Therefore, this special issue of Indian Journal of Fertilisers is devoted to the theme of Reliability in Power and Electrical Systems in Fertilizer Plants. There are eight papers in the issue highlighting the efforts made by the plant managements to improve the reliability and efficiency of captive power plants and electrical systems. We hope that all those concerned with operation and maintenance of fertilizer plants will find the information useful.■