Revamping 23-Year-Old Urea Plant

A successful attempt is illustrated in revamping urea plant capacity by 37.5% with special emphasis on selection of scheme and implementation, the two crucial steps in achieving the final goal.

V. S. Vaish and A. B. Sarkar
Indian Farmers Fertiliser Cooperative Ltd. (IFFCO) Kalol, Kasturinagar Dist., North Gujarat, India

Introduction

The IFFCO Kalol Unit operates M.W. Kellogg and Stamicarbon design ammonia and urea plants, respectively, since 1974. In 1997, after running the plants for almost 23 years, ammonia plant capacity has been increased from the original designed capacity of 910 MTPD to 1,100 MTPD and urea plant capacity from the original designed capacity of 1,200 MTPD to 1,650 MTPD.

The principal criteria to justify the revamp of any vintage plant is the necessity of the sound health of the plant’s critical equipment and piping. The urea plant at IFFCO Kalol was constructed by Humphreys & Glasgow, U.K. (now known as Jacob H&G) on a turnkey basis in 1973–1974 based on a CO\textsubscript{2} stripping total recycle process, developed by Stamicarbon bv of The Netherlands. In any urea plant, high-pressure equipment such as a urea reactor, a stripper, a condenser, a scrubber, a CO\textsubscript{2} compressor, ammonia pumps, carbamate pumps, and interconnecting high-pressure piping are critical and their health determines the residual life of plant and, therefore, the justification of a revamp. At Kalol, all critical equipment are the original ones except the high-pressure condenser, which was replaced in September 1993. The high-pressure equipment are inspected routinely by an in-house inspection group with a periodic inspection by Stamicarbon.

The sound health of these critical equipment prompted IFFCO to think of a cost-effective revamp of the urea plant. It is worth mentioning at this point that the stripper, the most corrosion/erosion prone equipment in any urea stripping process, is in service at IFFCO Kalol for 25 years, the longest period ever for any such equipment. Recent inspection of this critical equipment carried out in April 1998 reveals that the stripper still has a residual life of 3 to 4 years. Considering this, action has already been initiated for replacement of this critical equipment in the near future. Inspection history and health of high-pressure equipment in the urea plant prior to taking up of...
revamping activities in March 1995 is shown in Table 1.

Selection of Revamp Process

Revamp schemes are normally tailor-made for a particular plant. In-built capacities of existing equipment are assessed for the provision of a minimum number of additional equipment to meet the targeted enhanced capacity of the plant. No revamp scheme refers to finding proveness and reliability. This makes it more difficult to choose the perfect revamp scheme. In the case of the Kalol urea plant there was a capacity expansion from 1,200 MTPD to 1,650 MTPD (an increase of 37.5%). The revamped capacity of 1,650 MTPD was firmed up based on a preliminary end to end survey of the urea plant carried out by Stamicarbon in early 1994. The concept was based on a “more in-more out” philosophy taking advantage of maximum cushions available in various process equipment and supplementing deficit areas by modifications and replacement of certain equipment, as well as creating some add-on facilities to keep safety and economy in view. While reviewing the technology, options following basic criteria were kept in view.

- Minimum equipment so as to manage within the space available;
- No change in operating philosophy;
- Low investment per tonne of urea;
- Low emission levels and specific energy consumption per tonne of urea produced; and
- Minimum downtime to hook up new equipment and add on facilities.
- No additional steam requirement for increased plant capacity.

There were two options available for selection of a process consultant. Both technologies were based on the “more-in-more-out” concept for the same enhanced capacity but one of the consultants proposed add-on facilities consisting of a complete medium pressure section operating at 18 ata pressure in addition to modifications and replacement of certain equipment.

The Stamicarbon revamp scheme was chosen based on the following three important factors:

1. A minimum number of additional equipment in comparison to the offer of the other competitor. This was very important, because the existing plant, with a vertical layout and built-in space of just half the area (4200 M2) in comparison to the new generation plants, had hardly any space left for placement of new equipment. This factor was very much realized during erection of new equipment and related piping.

2. Stamicarbon, as the original process licensor, had access to the up-to-date data of the Kalol Urea Plant. Their offer was perfectly tailor-made for the revamp option, taking into consideration all the limitations including severe space constraint.

3. The confidence level of proven technology through original plant designer. Stamicarbon had been involved in all major troubleshooting activities right from commissioning of the plant in 1974 and inspection of critical equipment during various annual turnarounds.

The process flow diagram of the plant is shown in Figure 1 highlighting new equipment added with dotted lines.

Consultancy and Construction Agencies

The revamp project was approved by the government with the zero date as March 1, 1995 and completion within 30 months. Before signing the agreement with the Process Licensor, Stamicarbon was entrusted with the job for carrying out a detailed urea plant study. This was necessary to know the bottlenecks and plant capability to produce 1,650 MTPD on a continuous basis. The agreement for supply of “Basic Process Design package (BPDP)” and other engineering services was initial in September 1995 with Stamicarbon. For providing design, engineering and procurement (DEP) and site supervision services, agreement was made with Stamicarbon’s approved Indian Consultant Tecnimont ICB (TICB).

Construction and erection jobs were entrusted to reputed agencies like L&T (Mechanical Contractor), Gannon Donkerley (Civil Contractor), AEC (Electrical Contractor), and Blue Star (Instrumentation Contractor).
### Table 1. Inspection History and Health of High-Pressure Equipment in Urea Plant Prior to March 1995

<table>
<thead>
<tr>
<th>Sl No</th>
<th>High Pressure Equipment</th>
<th>Description</th>
<th>Health Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Reactor</td>
<td>Vessel</td>
<td>Good liner condition. Bottom hemispherical liner segment replaced due to leakage of nozzle - liner weld. Corrosion rate is 0.03 mm/year which is normal. All internals are in good condition. Weld defects observed on longitudinal and transversal weld of liner and tray support. Affected area grind and rewelded as per standard procedure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Year of Fabrication 1972</td>
<td>Liner material 316L Urea Gr X2CrNiMo 17.13.2 Urea Gr Liner Thickness - 5 mm Trays - 10</td>
</tr>
<tr>
<td>2.</td>
<td>Condenser</td>
<td>Shell &amp; tube heat exchanger</td>
<td>The equipment replaced by a new one in 1993. Material of construction of Tubes and Liner changed to X2 Cr NiMoN 25-22-2 from SS 316 L Urea Gr. Internals are almost like new after 3 years of operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Year of Fabrication - 1992</td>
<td>Liner &amp; tube material X2 CrNiMoN 25.22.2 Tube OD 25 mm Tube Thk - 2.5 mm No. of Tubes 1970</td>
</tr>
<tr>
<td>3.</td>
<td>Stripper</td>
<td>Shell &amp; tube heat exchanger</td>
<td>Corrosion rate is 0.06 mm/yr which is normal. Average tube thickness is 2.68 mm. Tube sheet and overlay condition are OK. Liquid entry holes on gas tubes (ferrules) increased from 2.3 mm to 2.5 - 2.6 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Year of Fabrication - 1972</td>
<td>Liner &amp; tube material X2 CrNiMoN 25.22.2 Tube OD 32 mm Tube Thk - 3.5 mm No. of Tubes 2100</td>
</tr>
<tr>
<td>4.</td>
<td>Scrubber</td>
<td>Shell &amp; tube heat exchanger</td>
<td>Corrosion rate observed 0.04 mm/yr which is normal. Weld defects observed on tube to tube sheet. Rectified by grinding and filling as per standard procedure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Year of Fabrication - 1972</td>
<td>Liner &amp; tube material X2 CrNiMo 17.13.2 Urea Gr. Tube OD 25 mm Tube Thk - 2.5 mm No. of Tubes 424 'U' tubes</td>
</tr>
</tbody>
</table>

### Engineering and Execution

During the kickoff meeting between the process consultant, Indian Consultant, and IFFCO, the following parameters and responsibilities were discussed and agreed to:

- Scope of Process Consultant under Basic Process Design Package (BPDP) and Scope of Indian Consultant during various stages of project execution.
- Layout of new equipment.
- HAZOP study of high-pressure section by the Process Licensor and remaining portion by Indian Consultant.
- Parameters for performance guarantee.
- Overall project schedule.

The remedial measures implemented in various sections to achieve the design capacity of 1,660 MTFD are summarized in Table 2 and also described individually in the following text.

### High-Pressure Section

**Urea reactor**

Harnessing the capacity of a urea reactor, which had 10 trays of original Stamicarbon design, was important to achieve higher conversion compatible with enhanced plant capacity. Prior to revamping, conversion efficiency of the reactor was in the range of 58% to 59%. To achieve conversion efficiency in the range
of 61% to 62% and with an ultimate aim to produce plus 1,650 MTPD, original trays were replaced with 11 Number modified trays fabricated and supplied by Schoeller Bleckmann of Austria based on Stamicarbon proprietary design. Overflow pipe inside the reactor was also replaced with a bigger size pipe to meet the requirement of higher flow rate.

**H.P. stripper**

The HP stripper, which has 2,100 tubes, has been in service for the past 25 years. However, hard scale deposit, mainly of iron oxide of 2–2.5 mm thick, got deposited inside the vertical tubes predominantly on the lower part. It was almost impossible to remove this hard scale by a mechanical means such as rubbing with a brush or hydrojetting. This was the cause of a gradual decrease of stripper efficiency, to a level of about 75% to 77% due to poor heat transfer. To improve the stripping efficiency, the HP stripper was chemically cleaned with EDTA solution by a Stamicarbon recommended agency, Houseman Metal Cleaning bv of The Netherlands. Around 1.8 tonnes of hard scale was removed, thus improving the stripping efficiency by about 2%.

To improve the liquid/gas distribution in stripper tubes, flow dividers were provided with orifices on all ferrules. The holes on old gas tubes which got enlarged due to a long service of 23 years were good enough for enhanced capacity; therefore, the same ferrules were used with a slight modification. Currently, the same old stripper is in service to produce more than 1,650 MTPD.

**H.P. condenser**

At an uprated capacity, the L.P. Steam generation pressure on the shell side was reduced from 3.6 kg/cm²g to 3.2 kg/cm²g to augment the additional duty in the HP Condenser. For flexibility in operation, the pressure control valve installed at the outlet of the steam drum has been shifted to the export steam header.
Table 2. Remedial Measures Implemented in Various Sections to Achieve Design Capacity of 1,650 MTPD

<table>
<thead>
<tr>
<th>SI No</th>
<th>Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High Pressure Section</td>
<td>• Installation of modified trays in reactor&lt;br&gt;• Chemical cleaning of HP stripper tubes &amp; modification to liquid distributors&lt;br&gt;• Reduction in LP steam generation pressure in HP condenser&lt;br&gt;• Reduction of passivation air in HP system&lt;br&gt;• Installation of N/C ratio meter&lt;br&gt;• Adoption of low pressure start up</td>
</tr>
<tr>
<td>2</td>
<td>Feed Pumping/Compression</td>
<td>• Installation of CO2 centrifugal compressor.&lt;br&gt;• Installation of one HP ammonia pump &amp; replacement of turbines of old pumps with motors.&lt;br&gt;• Installation of one HP carbamate pump &amp; replacement of turbines of old pumps with motors.&lt;br&gt;• Replacement of high pressure discharge pipes of ammonia and carbamate pumps</td>
</tr>
<tr>
<td>3</td>
<td>Low Pressure Section</td>
<td>• Modification in recirculation heater of rectifying column&lt;br&gt;• Additional condenser&lt;br&gt;• Increase of plates in plate heat exchanger&lt;br&gt;• Modification of operating system of flash tank&lt;br&gt;• Improved scrubbing of ammonia&lt;br&gt;• Addition of one small capacity ammonia - water tank</td>
</tr>
<tr>
<td>4</td>
<td>Evaporation &amp; Prilling</td>
<td>• Installation of pre-evaporator&lt;br&gt;• Replacement of evaporator, condenser and ejector in 1st and 2nd vacuum evaporator system&lt;br&gt;• Replacement of prill machine with modified prill bucket.</td>
</tr>
<tr>
<td>5</td>
<td>DCS Based Instrumentation</td>
<td>• Old pneumatic instrumentation was changed to electronic based instrumentation</td>
</tr>
</tbody>
</table>

**H.P. scrubber**

Air feed for a passivation purpose was reduced with respect to the O₂ content from 0.8% (v/v) to 0.6% (v/v), as per the recent standard of the Stamicarbon process, reducing the inert content by 25% in the synthesis section. This resulted in the availability of more effective volume in the reactor due to less accumulation of inert and also less loss of ammonia along with the inert through the final venting. The heat load on the H.P. Scrubber remained almost the same at the enhanced capacity of 1,650 MTPD; hence, no modification was required in the H.P. Scrubber.
N/C ratio meter

At the uprated plant capacity, it was all but certain that operating flexibility would be squeezed. To avoid process upsets, the N/C ratio meter developed jointly by Stamicarbon & ThIS Analytical b.v. of The Netherlands has been installed to monitor \( \text{NH}_3/\text{CO}_2 \) mole ratio in the reactor.

This is the first time that such an instrument is installed in India for precise control of a critical parameter in achieving the ideal operating condition in urea plant.

Low-pressure startup

To shorten the startup time and to avoid the severe noise pollution, which is a serious problem in an old Stamicarbon Urea Plant, modification has been carried out to adopt steam passivation and low-pressure startup. Originally recommended passivation and heating of an HP System by \( \text{CO}_2 \) at 60–70 kg/cm\(^2\) mixed with 1.00% (v/v) anticorrosion air has been replaced by a 9 ata steam heating and passivation system. By adopting this change, the passivation period is reduced from 14 h to 4 h and, during this period, the \( \text{CO}_2 \) compressor is not required to be run giving direct benefit of energy savings and pollution free startup.

Feed Pumping/Compression

\( \text{CO}_2 \) compressor

Before revamping, the Kalol Urea Plant was operating with two (1+1) reciprocating compressors of Peter Brotherhood, U.K. and GHH, Germany with a common centrifugal booster compressor for meeting the requirement of compressed \( \text{CO}_2 \) in a urea plant. These compressors were capable of compressing \( \text{CO}_2 \) for production of a maximum of 1,350 MTPD urea on a sustained basis. For meeting the additional requirement of \( \text{CO}_2 \), the following options were studied in detail:

1. Enhancing the capacity of existing compressors.
2. Installation of a small reciprocating compressor in parallel.
3. Running both the existing compressors in parallel at low load.
4. Installation of a centrifugal compressor of capacity equivalent to 1,650 MTPD.

Out of various alternatives, it was decided to opt for a full capacity centrifugal compressor to economize on steam balance and to eliminate additional power requirement to the tune of 1,920 KW. Moreover, installation of centrifugal compressor would ensure greater reliability in operation and provide a high onstream factor, as well as reduce downtime and maintenance cost. A full capacity centrifugal compressor is procured from Hitachi, Japan.

H.P. ammonia and carbamate pumps

Prior to revamping, the Kalol urea plant was operating with two (1+1) reciprocating Worthington make HP ammonia pumps each capable of delivering a maximum of 60 M\(^3\)/h of ammonia and two (1+1) reciprocating Worthington make HP Carbamate pumps each capable of delivering 28 M\(^3\)/h of carbamate. The pumps were equipped with steam turbine drives, except for one ammonia pump which was equipped with a motor. The initial option was to change the turbines with motor drives to match the steam balance in the urea plant and to run both ammonia and carbamate pumps in parallel at reduced capacity so as to get the desired combined flow of ammonia and carbamate for revamped plant load. However, this arrangement would have left no spare ammonia and carbamate pumps for this critical service. Options were many such as to add a similar capacity of one number each reciprocating type ammonia and carbamate pumps and to run two pumps in parallel at a reduced load with one pump as standby. Another alternative was to have a centrifugal type of one number each of ammonia and carbamate pumps for full capacity and keep the existing reciprocating pumps as standby. All these alternatives were well deliberated from the viewpoint of economic considerations, a change in operating and maintenance philosophy, and high operating cost. Both these alternatives were found not suitable to our system and also economically not viable as, in both the cases, pumps would have gotten much excess capacity never to be utilized and also motors needed 3.3 KV.
rating power supply, the network of which was not available within the urea plant battery limit.

Ultimately, the best option which emerged is given below:

1. Derate the existing capacity of ammonia pumps from 60 M$^3$/h to 45 M$^3$/h limiting the maximum speed and adding one new smaller size pump of 45 M$^3$/h capacity with (2+1) operating philosophy.

2. Derate the existing capacity of reciprocating carbamate pumps from 28 M$^3$/h to 22.5 M$^3$/h and to add a new smaller size pump of 22.5 M$^3$/h with (2+1) operating philosophy.

3. Remove steam turbines and change all the pumps to variable frequency AC LT motor drive system which would directly give an annual savings of $223,500 on operating cost with respect to other options.

One number of each reciprocating type of new ammonia and carbamate pumps and a variable frequency AC LT motor drive system were procured from Peroni, Italy. The combination of old and new pumps is running smoothly; moreover, 25-year-old pumps at reduced speed has resulted in less wear and tear of the pumps and longer life of the packing and valve assemblies. A complete analogue study of both ammonia and carbamate pumps including piping was also carried out before the supply of new pumps and frequency variable drives of existing pumps. This study was essential as this type of arrangement has no reference and is adopted for the first time in the world where two dissimilar new reciprocating pumps are added to the existing pumps with de-rated capacities. Again, IFCO Kalol is the first plant in India where the frequency variable AC LT motor drive system has been tried successfully on H. P. ammonia and carbamate pumps.

**High-pressure piping**

The discharge piping of both H. P. ammonia and carbamate pumps, which were 23 years old, have been changed from 4 in. to 6 in. and 3 in. to 4 in. sizes, respectively, from a reliability point of view and to accommodate the enhanced flow rates with permissible pressure drops.

**Low-Pressure Section**

**Recirculation heater modification**

The LP decomposer heater is a vertical heat exchanger where process stream is heated by 4 ata steam. The driving force for process fluid movement is by thermosyphon action. The requirement of higher heat transfer to meet the revamp capacity heat load needed replacement with a bigger size heat exchanger. An innovative method was adopted to increase the heat-transfer rate by installing orifices at the bottom of each of the 1,030 vertical tubes. The orifices act as an ejector thereby increasing velocity of process fluid and higher heat-transfer rate by about 30%. The modification adopted is shown in Figure 2.

**LP condenser in series to existing L.P. condenser**

The best and most economical option to make up shortfall of condensing capacity of vapor in low-pressure section was to install an additional L.P. condenser in series to the existing L.P Condenser rather than going for a single bigger capacity condenser. The new condenser is falling film type capable of removing additional heat duty of 30% due to increase in process vapor load at enhanced capacity. The equipment was procured from L&T. Erection of the equipment was at the height of 18 meters by the side of the old condenser to have the minimum pressure drop. The RCC columns were up to height of 7 meters only, which were strengthened by reinforcing them. Structural framework was then erected above the reinforced columns to accommodate the equipment at 18 meters height.

**Plate heat exchanger modification**

Heat of condensation in a low-pressure system is removed by closed-loop circulating condensate which releases the heat to cooling water in a plate type exchanger. Additional 46 plates are added to increase the capacity of the exchanger to meet the higher heat load.
**Flash tank**

The flash Tank is last purification stage for removing traces of ammonia and CO₂ from the main product stream. To reduce the load on the Hydrolyzer and also to ensure admission of a smaller quantity of water to the system, the operating pressure of the Flash Tank was changed from vacuum to atmospheric pressure. Flashed condensate containing substantial ammonia was recycled back to the L.P. System for recovery of ammonia instead of being sent to the Hydrolyzer section through the Waste Water Tank.

**Improved scrubbing system**

Existing scrubbing of ammonia to reduce loss to atmosphere is improved by a higher flow rate of lean ammonia water solution to the scrubbers and recovery of vent gases from the low-pressure section by diverting the gases to the flash tank condenser. By this modification, ammonia losses are restricted to 0.4 kg/te of product only.

**Ammonia water tank**

One small tank of 15 M3 capacity is added by the side of the main tank for the purpose of separating lean ammonia water (4% NH₃ conc) received from the evaporation section and strong ammonia water (7% NH₃ conc) after scrubbing of ammonia from the HP and LP System. This improves the scrubber performance.

**Evaporation and Prilling**

**Pre-evaporator**

To harness the overall capacity of evaporation section for handling increased production, the Pre-Evaporator, Pre-Evaporator Condenser, and associated piping and instrumentation have been installed to increase urea solution concentration from 72% to 82% in the Urea Solution Tank utilizing the heat from process. The evaporator package with two heat exchangers in series (one part for heat transfer with process heat, that is, heat of condensation recovered from the HP Scrubber, and another part for heat transfer with 4 ata steam generated from process heat in HP Condenser) was procured from GR Engineering, Mumbai, India, and Vacuum Condenser from Graham, USA. The Evaporator Section with Pre-Evaporator is shown in Figure 3. Erection of the equipment weighing around 120 Tonnes was a difficult task as placement of the equipment was at a height of 18–25 meters with minimum process flow path to prevent high Biuret formation. Finally, some old civil engineering drawings revealed existence of civil foundations and structure on North West side of the Prilling Tower.
Table 3. Total Project Cost

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Item Description</th>
<th>Rs Million</th>
<th>US Dollar Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Design, Engineering &amp; Consultancy fee</td>
<td>41.2</td>
<td>1.20</td>
</tr>
<tr>
<td>2.</td>
<td>CO2 Centrifugal Compressor package</td>
<td>264.9</td>
<td>7.56</td>
</tr>
<tr>
<td>3.</td>
<td>HP Ammonia &amp; Carbamate Pump with Variable Speed Drive &amp; Drive conversion of existing pumps</td>
<td>47.7</td>
<td>1.35</td>
</tr>
<tr>
<td>4.</td>
<td>Prilling Machine with Prill Buckets</td>
<td>9.3</td>
<td>0.27</td>
</tr>
<tr>
<td>5.</td>
<td>Vacuum Condensing System</td>
<td>26.9</td>
<td>0.77</td>
</tr>
<tr>
<td>6.</td>
<td>Evaporator package</td>
<td>20.4</td>
<td>0.58</td>
</tr>
<tr>
<td>7.</td>
<td>Urea solution pumps, Lean Carbamate pumps, Process water pumps &amp; Ammon. Vent scrubber pumps</td>
<td>4.0</td>
<td>0.11</td>
</tr>
<tr>
<td>8.</td>
<td>LP Carbamate Condenser</td>
<td>6.5</td>
<td>0.19</td>
</tr>
<tr>
<td>9.</td>
<td>Strong Ammonia Water Tank, Urea Solution Tank and Lean Carbamate vessel</td>
<td>2.2</td>
<td>0.06</td>
</tr>
<tr>
<td>10.</td>
<td>N/C Ratio Meter &amp; Water in Carbamate analyser</td>
<td>9.9</td>
<td>0.28</td>
</tr>
<tr>
<td>11.</td>
<td>Modified reactor trays</td>
<td>9.1</td>
<td>0.26</td>
</tr>
<tr>
<td>12.</td>
<td>Chemical cleaning of Stripper</td>
<td>3.1</td>
<td>0.09</td>
</tr>
<tr>
<td>13.</td>
<td>Heat exchanger modification</td>
<td>0.9</td>
<td>0.03</td>
</tr>
<tr>
<td>14.</td>
<td>EOT Cranes</td>
<td>2.8</td>
<td>0.08</td>
</tr>
<tr>
<td>15.</td>
<td>Urea DCS</td>
<td>14.8</td>
<td>0.42</td>
</tr>
<tr>
<td>16.</td>
<td>Instrument items such as Smart transmitters, I/P &amp; P/I converters, Pressure gauges, Rotameters, Orifrices, Magnetic Flowmeter Cabinets etc</td>
<td>6.6</td>
<td>0.19</td>
</tr>
<tr>
<td>17.</td>
<td>Control &amp; Safety valves</td>
<td>11.2</td>
<td>0.32</td>
</tr>
<tr>
<td>18.</td>
<td>Pipes, Fittings &amp; Valves</td>
<td>56.9</td>
<td>1.63</td>
</tr>
<tr>
<td>19.</td>
<td>Mechanical, Electrical &amp; Instrumentation Erection Cost</td>
<td>24.9</td>
<td>0.69</td>
</tr>
<tr>
<td>20.</td>
<td>Civil &amp; Structural jobs</td>
<td>17.7</td>
<td>0.51</td>
</tr>
<tr>
<td>21.</td>
<td>Insurance, Bank charges &amp; Financing charges</td>
<td>18.2</td>
<td>0.52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>598.0</strong></td>
<td><strong>17.09</strong></td>
</tr>
</tbody>
</table>

Conversion rate 1 US$ = Rs. 25/-

which was meant for the bucket elevator system abandoned and removed around 18 years earlier. Structural columns of this area were strengthened by encasing with additional structural columns. The existing encased structures were extended to accommodate the complete package at a height of 18-25 meters. In addition to above, the following changes have also been incorporated:

- Increase in capacity of urea solution tank by adding a smaller tank by the side of existing tank.
- Replacement of existing urea solution pumps with higher capacity suitable for higher concentration.

**First and second effect evaporator system**

To de-bottleneck the capacity of maintaining vacuum at high load, Stamicarbon recommended replacement of second-stage evaporator and some critical condensers/ejectors of the complete vacuum system. The equipment were procured from Graham, USA and GR Engineering, Mumbai, India. Due again to a space constraint, the erection of the equipment of higher dimensions and at a height of 25 mts was a difficult and challenging job. Weight and size of the new equipment was more than the old one, so it was decided to change the load distribution pattern by reselling the equipment on structural beams fixed to the vertical concrete columns instead of reselling them on concrete floor similar to the old one. For achieving this task, a 200 tonne capacity crane was utilized by the erection contractor L&T to remove the existing equipment and install new ones. GDC, the civil contractor, provided services for broadening the slots and making the equipment foundations suitable for changed dimensions. All the in-situ jobs at a height of 25 meters including equipment erection was carried out in just 8 days.

**Prilling system**

One of the biggest limitation at Kalol is its induced draft Prilling Tower which has a total free fall height...
of only 50 meters having an internal diameter of 17 meters. Due to the Prill Tower size limitation, the prill temperature at the bottom of the tower remains in the range of 85–90°C even at plant capacity of 1,200 mtpd especially in Summer.

To overcome this problem, a fluidized-bed Prill Cooling System was installed in 1988 to get a prill temperature of 60–65°C before sending the product to the Silo/Bagging Plant. Taking advantage of the Prill Cooling System, Stamicarbon suggested installation of the modified Prill Bucket to make the existing Prill Tower suitable to achieve a higher prill production rate with marginal sacrifice on prill size. Guaranteed size was 1.6 mm (mean prill dia) with respect to 1.7 mm before revamp. During detailing, changing over to the modified Prill Bucket also called for complete replacement of the Prilling Machine which is supplied by the Stamicarbon approved vendor Machinefabriek Kreber of The Netherlands. The daily production of about 1,750 MT is now being processed through the same 25 year old Prilling Tower with a mean prill diameter of 1.4–1.5 mm.

Figure 3. Evaporation section with pre-evaporator.
DCS-based instrumentation

Under the expansion and modernization scheme, 23 years old pneumatic instrumentation has been changed to Microprocessor-based instrumentation incorporating a Distributed Control System (DCS). Yokagawa's Centum CS System has been selected. The system has many unique features like single-loop integrity for controllers, hardware on a unix platform high resolution CRT and a more user-friendly man-machine interface. The system has window in window features, a half size windows facility, four windows on a single CRT screen facilitating modulation of 4 x 8, that is, 32 controllers from a single page. The system employs 84 closed loops, 150 4-20 mA open loops, 160 temperature open loops, 304 digital input loops and 64 digital output loops.

Replacement of Control Valves

A total of 21 Control Valves were procured from Parcol, Italy. Out of these, 10 control valves were meant for the replacement of existing ones and 11 as new installation. These were considered to match increased production and facilitate safe and precise control of process parameters.

HAZOP Study

The Hazop study of the plant was carried out by Stamicarbon to check the adequacy of the existing high-pressure system for revamped capacity. After thorough checking of various high-pressure equipment, piping and control valves, the Consultant certified that the incremental increase of system pressure by about 4 to 5 kg/cm² after revamping will be within the safe operating limits.

Tie-In Points

As soon as various schemes were firmed up, it was decided to take tie-in points in the existing plant for hooking up the schemes when the equipment was available. There were in all 140 Tie-In Points for which material was procured and arranged well in advance. The Tie-In connections were taken as and when opportunity arose in the Urea plant during periodic shutdowns. This strategy worked well as most of the schemes could be hooked up within the time schedule and in the running plant. Other than the annual turnaround, the Urea plant was not shut down for hooking up of any expansion scheme.

Urea Plant Revamp Cost

Out of the total project cost of $42.77 million for the Kalol expansion project, the cost toward Urea plant revamp was $17.09 million. Breakup is given in Table 3.

Performance

The plant was commissioned for revamped capacity in August 1997 well within the cost and time schedule. The Guarantee Test Run was successfully performed in February 1998 in the presence of Stamicarbon & TICB engineers meeting all the guarantee figures as listed in Table 4. Presently, the plant is producing around 1,750 MTPD on continuous basis and maximum production achieved recently was 1,800 MTPD.

Economics

The total capital cost for revamp of Ammonia and Urea plants at IFFCO Kalol was $42.77 million out of which cost incurred for Urea plant expansion was $17.09 Million, which is 40% of the total revamp cost. The specific capital cost investment per tonne of urea for the incremental production of 1,48,500 tonne per annum of urea at the total cost of $42.77 million works out to $288 as compared to $614 per tonne of urea for a 7,26,000 tonne annual capacity grassroot project, assuming present day investment of $448 million.

Conclusion

The successful revamping of the 23 year old Vintage Urea Plant at Kalol shows the possibility of revamping well maintained similar Urea Plants at a very reasonable cost. Last, but not least, judicious planning, training of operating and maintenance staff, as well as proper selection of technology for revamp, is a must.