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Improving Efficiency and Reliability through Process Modifications

The Saga of NFL Vijaipur

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The purposes of Modification Schemes are mainly for improvement in plant efficiencies, troubleshooting and operational flexibilities. At NFL Vijaipur, continual improvement is the basic philosophy.But before implementation, the schemes need a thorough scrutiny and study, especially from safety point of view, as otherwise the schemes may prove to be counterproductive. Keeping this aspect in mind, at NFL Vijaipur, there is a well- defined procedure for implementation of Modification and Suggestion Schemes.The Schemes are initiated by individual Departments/ Sections/Plants and evaluated by Technical Services Department before approval of the Scheme by the Competent Authority. Further, the approved Suggestion Schemes from individual employees are suitably awarded and regularized under Modification Schemes. Modification Schemes, initiated by Technical Services Department, are deliberated by concerned Departments before obtaining approval of Competent Authority. Main emphasis is given to the schemes those results in improvement in plant reliability, operation, safety and energy savings. During last three years, a total of seventy five modification schemes were implemented out of which thirty nine schemes have been briefed in the paper.

Introduction

The Vijaipur Unit of M/s National Fertilizers Limited operates two ammonia plants, each of reassessed capacities of 1520 MTPD and two urea plants, each of a reassessed capacities of 2620 MTPD. First Natural Gas based fertiliser unit on the cross-country Hazira-Vijaipur-Jagdishpur Natural Gas pipeline. The foundation stone was laid on 31st May1984 by the then Prime Minister of India, Late Mrs. Indira Gandhi. Vijaipur-I was commissioned in December 1987. After a decade, Vijaipur-II was commissioned in March 1997. Vijaipur-I and Vijaipur-II plants have been revamped w.e.f. 24.4.2012 and 31.07.2012, respectively.

The post revamp rated capacities of each of the plants is indicated in **Table 1.**

Process and Configuration of Plant

Both the Ammonia plants and urea plants are based on technology from M/s HaldorTopsoe, Denmark and M/s Saipem Italy, respectively. Both the ammonia plants are based on process of Steam Reforming of Natural Gas. The basic process route followed in both the ammonia plants is hydro-desulphurisation-primary reforming-secondary reforming-CO Shift Conversion-CO_2 Removal- Methanation-Ammonia Synthesis. However, Vijaipur-II Ammonia plant has dual feed facility with usage of maximum 50% naphtha as feed on energy basis and is more energy efficient because of incorporation of certain in-built energy saving features e.g. installation of gas turbine driven process air compressor along with Heat Recovery Steam Generator (HRSG) boiler, MP process condensate stripper, two stage Giammarco Vetrocoke (GV) process for CO_2 removal.

Both the urea plants are based on Saipem's ammonia stripping process. Each plant is laid in two streams of identical capacity with common prilling and auxiliary facilities. The basic process route followed is High Pressure CO_2 Compression and Liquid Ammonia Pumping- High Pressure Synthesis and Stripping- Medium and Low Pressure Decomposition of Ammonium Carbamate alongwith associated recovery and Ammonium Carbamate Recycle-Vacuum Concentration of Urea Solution-Prilling. The effluents those are generated in the system are treated in waste water treatment section and the treated process condensate is sent to DM plant for recycling after polishing. The major changes those were incorporated in Vijaipur-II plant with respect to Vijaipur-I are (i) Installation of high pressure

Table 1 – Pre and post revamped capacities

Plant	Pre-revamp rated capacity MTPD	Post revamp rated capacity MTPD
Ammonia-I	1520	1750
Urea-I	2620	3030
Ammonia-II	1520	1864
Urea-II	2620	3231
CDR	Not applicable	450.

(100Ata) steam turbine driven CO_2 compressor instead of medium pressure(40Ata) one.

Vijaipur unit is self-reliant in power. Gas Turbine Generators (GTGs) coupled with HRSGs ensure uninterrupted power supply as well as efficient use of gas turbine exhaust gases for raising steam in HRSGs supported by supplementary firing. In the GTs as well as HRSGs there is provision for use of liquid fuels, viz. naphtha. There are other auxiliaries, viz. water treatment plants; cooling towers; atmospheric ammonia storage tank; instrument & service air system; effluent treatment and management systems; etc. Elaborate conveying system along with bagging plant ensures dispatch of urea produced. Silos are there to ensure uninterrupted operation of plants in the event of dislocation of supply of railway rakes by Indian Railways.

A full-fledged township with all facilities is there for the employees to cater to their all needs.

Vijaipur-I as well as Vijaipur-II Plants have been revamped and specific energy consumptions in both the plants have reduced because of energy saving features incorporated in the revamp.

Modification Schemes Implemented in Last Three Years

Total 75 nos of modification schemes were implemented in last three years besides revamp of Vijaipur-I and Vijaipur-II. As it shall not be possible to give details of all the modification schemes, brief account of thirty nine modification schemes have been presented in this paper.

♦ *Utilization of C-3 Off gases of Urea-II as supplementary fuel in Heat Recovery Unit of Captive Power Plant*

At NFL Vijaipur, urea manufacturing is based on Saipem's ammonia stripping process. The raw materials for urea are ammonia (NH_3) and carbon dioxide (CO_2). CO_2 from Ammonia Plant contains small quantity of H_2, N, CH_4 and Ar gases. Besides, small quantity of air is also introduced along with CO_2 for the purpose of passivation of stainless steel surfaces against corrosion. Only part of O_2 in the air is utilized in forming the passivation layer. The excess air along with N_2, CH_4, H_2, Ar do not take part in any reaction and have to be vented out continuously. These off gases are vented from Medium Pressure (MP) section inert washing column (C-3). This also helps to maintain the MP loop pressure. C-3 off gases comprises 25-30% hydrogen, 7-10 % methane, 5-10% ammonia, 50-55% nitrogen and 6-10% argon. Each stream of urea plant generates around 500 Nm^3/h of C-3 off gases. Hence, total generation of C-3 off gases from all the four streams of urea plant is around 2000 Nm^3/h. This gas has a net calorific value of 1464 kcal/Nm^3 and hence contains a total heat value of 2.94 GCal/h. In view of considerable heat value of C-3 off gases, it was proposed to utilize these gases as supplementary fuel along with NG in heat recovery boilers of captive power plant.

The total scheme was developed in-house. An in-house HAZOP study was also conducted. The scheme was implemented in phases. First phase was implemented in June, 2011 while the second phase was implemented in August, 2012. The schematic diagram of the scheme is given in **Figure 1**.

In phase-I, C-3 off gases of urea plant of Vijaipur-I were used as supplementary fuel in HRU-II, the second phase, C-3 off gases of urea plant of Vijaipur-II were used as fuel in HRU-III and, now it is possible to use the off gases of Vijaipur-I as well as Vijaipur-II as supplementary fuel in all the three HRSG boilers after mixing with NG. The scheme involved a total investment of Rs 70 lakhs and resulted in an energy savings to the tune of 2.8GCal/h corresponding to financial saving of Rs 4.43 crores per annum @ energy cost of Rs.2000/Gcal and simple payback period of 1.5 months only. Besides, environment benefits of 23500 MT CO_2 emission per annum and comparatively lower NOx emission has been achieved .

♦ *Resolving Problem of Improper Dew Point of Instrument Air*

There are three instrument air compressors IAC-I, IAC-II & IAC-III in ammonia plant of Vijaipur-I. Out of the above three compressors, IAC-III is dedicated for supply of additional 6000 Nm^3/h process air requirement after revamp. The other two compressors are continuously operated to meet the instrument air requirement in Vijaipur-I. Hence, all the three instrument air compressors are continuously operated to meet the instrument air and process air requirement.

At this load the suction temperature of 2nd, 3rd & 4th stage of IAC-I /II and the final discharge temperature of IAC-I & II were running on higher side (60°-65°C) against the design value of (40°C). Problem of higher dew point of instrument air (-15 to -30°C) against the design value of (-40°C) and moisture carryover was observed in instrument air header. The problem aggravated during hot and humid conditions. Any moisture carry over might lead to malfunctioning of instruments and tripping of plants and increase in unproductive energy. Procurement of any new system would have taken a long time and required investment. Hence, in-house study was made to solve the problem. It was observed after calculations that the old 2nd stage intercooler (41 E-26) and associated separator (41MV16) which had become redundant after revamp of Vijaipur-II urea plant were adequate to cool and separate the moisture content in the instrument air. The said exchanger and separator were installed at the common discharge header of IACs to cool the air to 40°C for separation of water vapors before

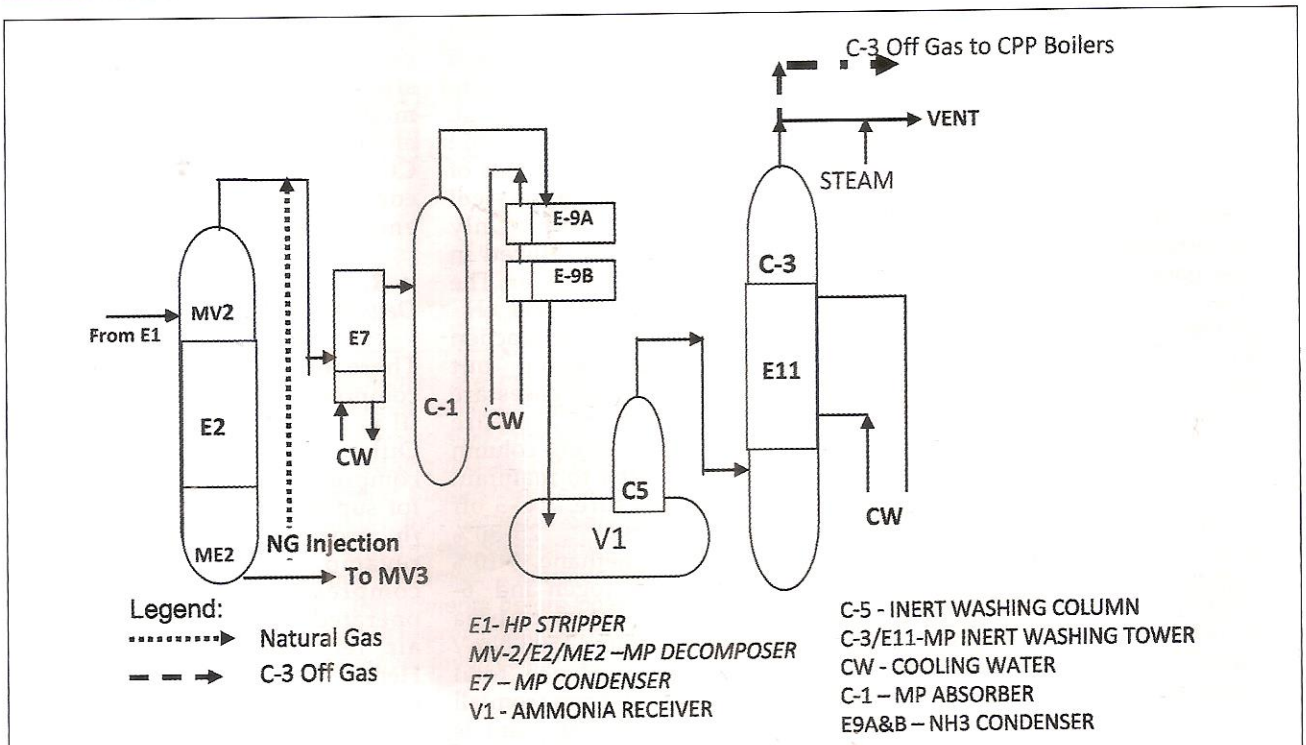

Figure 1 – Utilisation of C-3 off gases as supplementary fuel in CPP boilers

Instrument Air Dryers. The photograph and schematic diagram of the scheme are shown in **Figures 2 and 3,** respectively. The scheme was implemented in 2013-14 with total investment of Rs.5 lakhs. After this modification, the System has improved and dew point after final discharge cooler is coming between -40°C to -60°C. The moisture is getting separated in final stage separator. No moisture carry-over has been observed thereby improving plant operational reliability by way of eliminating the possibility of any tripping of the plant arising out of malfunctioning of instruments.

Additionally, there has been financial saving to the tune of Rs.15-20 lakhs due to non-procurement of any new system.

♦ *Removal of NRV from CO_2 export line*

It had been observed that in Ammonia-II plant battery limit pressure of product CO_2 was maintained as high as 0.7 kg/cm² to meet the urea plant CO_2 battery limit pressure at the present urea plant load. This pressure is quite high and putting load on CO_2 blower and might lead to limit the supply of CO_2 if pressure goes further high due to higher CO_2 flow or due to high CO_2 temperature.

In order to analyze the problem, pressure drops were measured at different points in final CO_2 product line. The pressure drop across battery limit Non-Returning Valve (NRV) found to be around 0.035 kg/cm² whereas pressure drop across 33FT32 orifice was found to be around 0.065 kg/cm²g making total pressure drop of around 0.1 kg/cm² in this line which is very high. In view of the above, to avoid CO_2 blower overloading, the existing NRV was removed. After this modification, no overloading of CO_2 blower was observed and there was improvement in suction pressure of the CO_2 compressor.

♦ *Energy saving by application of energy saving coating inside the Casing of Cooling Water Pump of Line-II*

There are total 12 numbers of Cooling Water Circulation Pumps at NFL Vijaipur, out of which 8

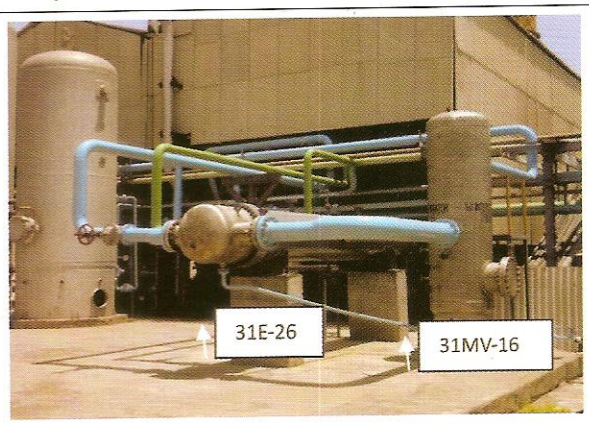

Figure 2 – New final stage cooler & separator

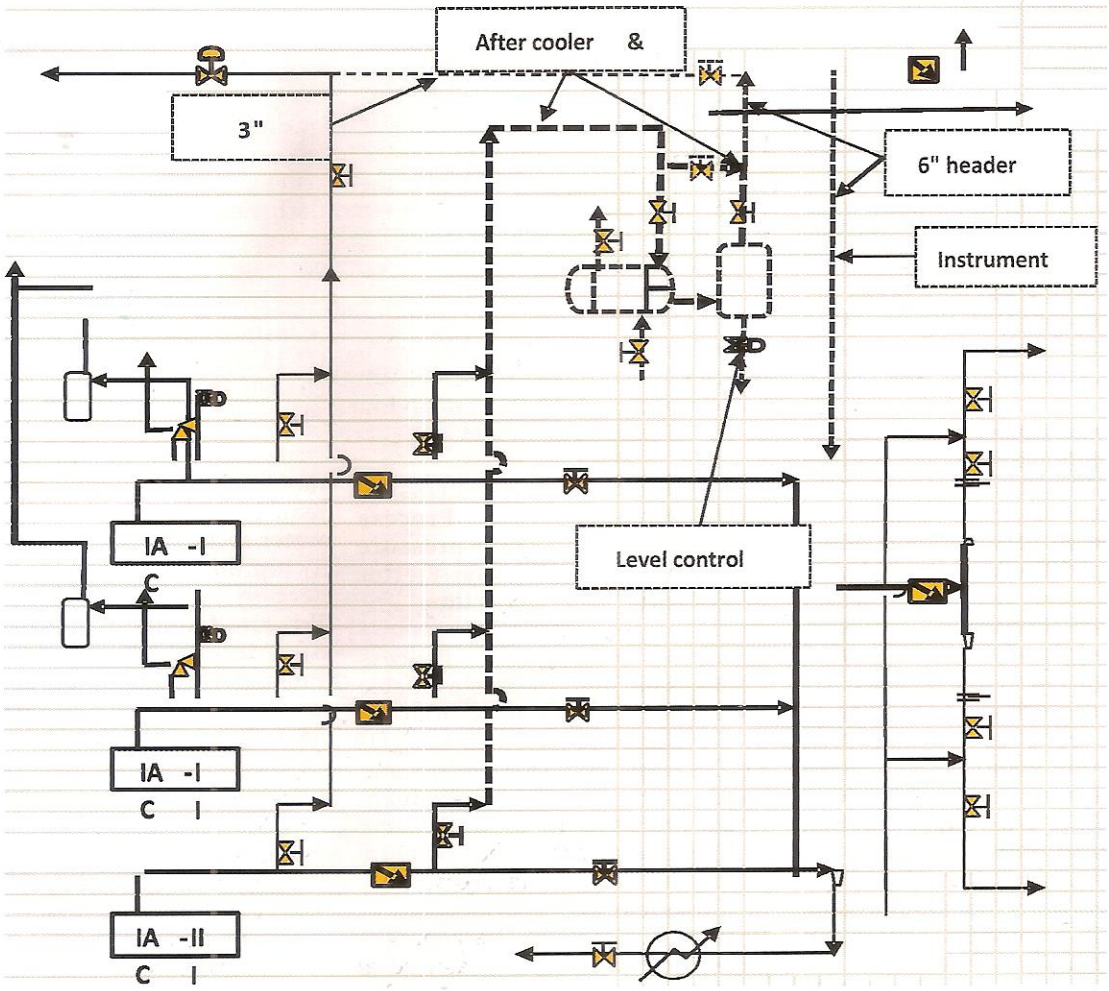

Figure 3 – Schematic diagram of the Scheme for installation of 31E-26 & 31 MV-16 for resolving the problem of improper dew point of Instrument Air.

remains in line and four pumps as standby. As the impellers of all the pumps are of stainless steel make, there shall not be any gain in energy in case of application of coating in the impellers. Hence, it has been decided to apply energy saving coating in the casings of the pumps which would reduce roughness of the surfaces and result in power saving by 2-3%. The total investment in the scheme was Rs.2.6 Lakhs/pump.

♦ ***Replacement of Glass Reinforced Plastic (GRP) blades with Fibre Reinforced Plastic (FRP) blades (hollow fibre material) in Cooling Tower fans***

There are total 22 number of induced draft fans with GRP blades in Vijaipur-I and Vijaipur-II cooling towers. In view of the fact that GRP blades are heavy and draw more power, it was decided to replace these blades with hollow light weight FRP blades. Blades of all the 22 fans have been replaced with FRP blades. Approximately 20% power saving has been achieved with 15% additional flow after replacement of the fans. Total investment in the Scheme was Rs. 34 lakhs with financial savings of Rs. 60 lakhs and simple payback period is 5 months.

♦ ***Energy saving by replacement of existing bowl with Modified bowl in one of the Raw Water pump at Raw Water Reservoir***

There are total five numbers of vertical Turbine Pumps (PC1A-E) at raw water reservoir to transfer raw water for plant requirement and partially for the storage in raw water reservoir. These pumps used to deliver very less flow (700-800 m^3/h) as compared to their design capacity of 1500 m^3/h. The combination of any two pumps used to deliver about 1300 m^3/h only. Therefore, two pumps were running almost on continuous basis to meet the plant requirement against requirement for operation of single pump. In view of this, a modified bowl was procured and installed for one of the pump (PC-1C). This reduced continuous running of combination of two pumps throughout the day to meet

the plant water requirement and thereby saving in energy as well as maintenance cost. The pump has been successfully running since November, 2009.

Implementation of the scheme has resulted in saving of 1675 kWh/day electricity which is equivalent to an energy saving of approximately 600 GCal/annum corresponding to financial saving of Rs. 9 lakhs per year. Encouraged by the results, a new bowl has been procured for pump (PC-1B) also.

♦ *Interconnection between P-10 and P-13 pumps of Urea Plant of Vijaipur-II*

In urea plant of Vijaipur-II, P-10-A/B pumps have been provided to supply low pressure water required for flushing of LP loop & purging of Level Transmitter (LT) provided in low pressure equipments. There are also 2 numbers of P-13 pumps (one normal+ one standby) in Urea-II plant which export condensate to DM plant. It was observed that operation of only one pump can solve the purpose. Capacity of P13 pumps are more as compared to that of P-10 pumps. Hence, an interconnection between the discharge lines of P-10 and P-13 pumps was provided which resulted in stoppage of P-10 pump. By implementing this scheme, energy saving of 15kWh corresponding to financial saving of Rs. 2 lakhs per annum was achieved.

♦ *Energy saving by transfer of Process Condensate of Urea Plants to DM Plant by Pressure Difference*

In waste water section of urea plant of Vijaipur-I and Vijaipur-II, P-18 pumps have been provided to transfer the treated process condensate from urea plant to De-Mineralisation (DM) plant. However, during conductance of in-house energy audit, it was observed that the condensate can be transferred from urea plants to DM plant by pressure difference including available head. On trial basis the pumps of urea plants were stopped to transfer the condensate. However, it was observed that the transfer line is undersized to transfer the process condensate of both the plants. Hence, a new separate header was laid. After laying the new header, it has been possible to transfer the condensate to DM plant from urea plants of Vijaipur-I as well as Vijaipur-II by pressure difference plus available head. The scheme was implemented with total investment of Rs.10 lakhs with energy saving of 47kWh corresponding to financial saving of Rs 4.5 lakhs per annum.

♦ **Generation of low Pressure steam by increasing Process Condensate Tank (V-2) pressure and utilization of Booster Ejector of 11stream Vacuum section**

In Urea-I plant one Process Condensate Tank (V-2) is available for collecting condensate from 11/21 E-5 (Carbamate condenser), 11/21 E-3 trap, 11/21 E-14/ E-15 and condensate from tracing steam traps. Process Condensate Tank (V-2) is operating at a temperature of around 98-100°C and pressure of 0.18kg/cm^2. Design pressure of Process Condensate Tank (V-2) is 3.0 kg/cm^2 (abs) and temperature is 140°C. V-2 condensate is used as make up in 11/21E-5, Low pressure flushing water/ Medium pressure flushing water / Higher pressure flushing water (LW/HW/KW) flushing, for Level Troll (LT) flushing in Stripper/ MP Absorber and for de-superheating. Excess condensate is exported to CPP as DM water make up. To maintain the pressure of V-2, an overhead exchanger (E-13) is provided to cool the flash vapors generating inside the vessel by cooling water.

To utilize this untapped energy which is being lost to CW, it was proposed to increase the pressure of V-2 tank up to 1.5kg/cm^2, correspondingly increasing temperature up to 120°C. The low pressure steam so generated is then used in Booster Ejector (11 EJ-02). For this modification, following changes are carried out: Laying of 3" header from V-2 to 11 vacuum section. One isolation valve near urea hydrolyser (R-2). One isolation valve with NRV near booster ejector.The scheme was implemented with total investment of Rs. 6 lakhs. The scheme generates around 1 te of flash steam which is equivalent to energy saving of 4158 GCal/annum corresponding to financial saving of Rs. 5.0 lakhs /annum.

♦ *Installation of additional Pumps (P-15 A/B) from surplus pump of Urea-II Plant in the post revamp of Vijaipur-I*

Urea-I plant is having two numbers of P-15 pumps to circulate lean ammonia solution to waste water section distillation tower (C-2) top and to 11/21 low pressure section as absorbent at Low Pressure Carbamate Condenser (E-8) inlet. After Capacity Enhancement Project, the waste water load on C-2 increased from 58 Te/hr to 72 Te/hr and both the P-15 pumps had to be run continuously to meet the requirement with no spare available. Procurement of new/ modified pump would have cost more than Rs 50 lakhs. A surplus pump (P-15) which was available in Urea-II after revamp, was installed in Urea-1 along with existing pump (P-15 A/B). The scheme was implemented with total investment of Rs. 20,000.

♦ *Modification in Stripper and (medium Pressure condenser (E-7)*

In Urea-I plant, after capacity enhancement project, plant is running on higher load and it was observed that stripper bottom temperature was around 202°C, shifting the decomposition load in MP section. In 11/21, MPD decomposition section, due to higher decomposition load, Medium Pressure Condenser (E-7) solution outlet temperature and ammonia receiving tank (V-1) temperature are on higher side. All these conditions increase the vapor load in MPD and subsequently, Medium pressure off gas vent valve (PV-108) opening.

To encounter this problem, following modifications were

Figure 4 – Fresh CW injection for E-7

Figure 5 – Depicting modification in MP-4801C

carried out in urea-1. Provision of separate cooling water injection in Medium Pressure Condenser (E-7) as show in **Figure 4** and De-plugging of total tubes in E-7 which were earlier plugged after installation of pre-concentrator. Modification of stripper ferrules as suggested by M/s Saipem will be carried out after receipt of ferrules. This scheme had improved process operating condition and achieved energy saving.

♦ ***Conversion of Cooling Water Circulation Pump winding temperature Cooler from (CACA) Cooling Air with Cold Air to (CACW) Cooling of Air with Cooling Water***

New CACW heat exchanger for MP4801C motor (11kV, 1300kW) was procured from M/s Kirloskar Electric, Bangalore to increase motor capacity from 1300kW to 1450 kW in Urea-II CT as shown in **Figure 5**.

A gate valve along with a flow orifice was installed to control the water flow with total Investment of Rs 12 lakhs. By implementing this Modification, the desired output power of 1.45MW has been obtained and procurement of a new motor with estimated cost of Rs.80 lakhs have been avoided, thereby saving of Rs 68 lakhs.

♦ ***Modifications in Medium Pressure Off Gas Scrubber/Heat Exchanger (C-3/E-11) Level Troll in Urea-I and Urea-II***

Off gases of C-3/E-11 are being utilized as supplementary fuel in CPP boilers. Concentration of ammonia in off gases was around 5-10%. In order to further reduce the concentration of ammonia in C-3 Off gas, vapor inlet line inside C-3/E-11 extended downwards so that it will remain dipped inside the solution for better absorption of ammonia. Normally level is maintained around 50-60% as per Level Troll, which was not sufficient for absorption of ammonia. It was thought to increase the level further in C-3 to increase the ammonia absorption and subsequent reduction of ammonia content in C-3 Off gas, but level was going above the range of Level Troll. In order to maintain higher level at C-3 bottom, Differential Pressure Transmitter (DPT) was provided as shown in **Figure 6**. With this arrangement level could be increased up to the bottom of E-11.

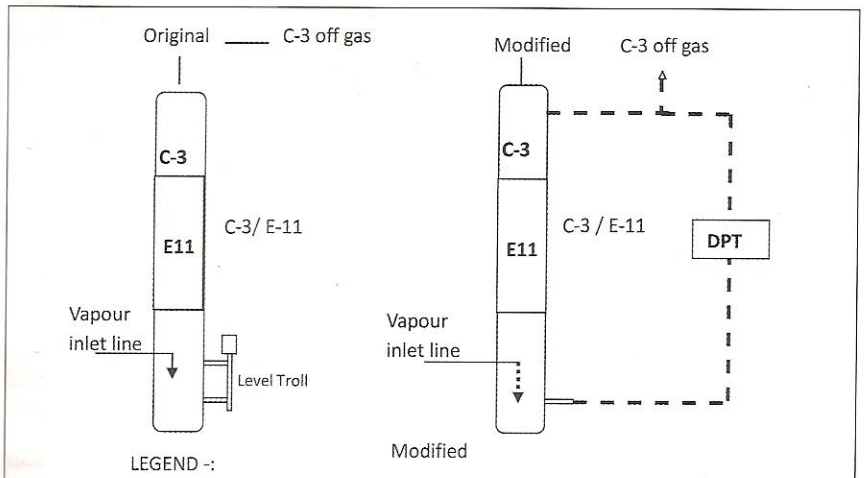

Figure 6 – Modification in C-3/E-11 Level Troll

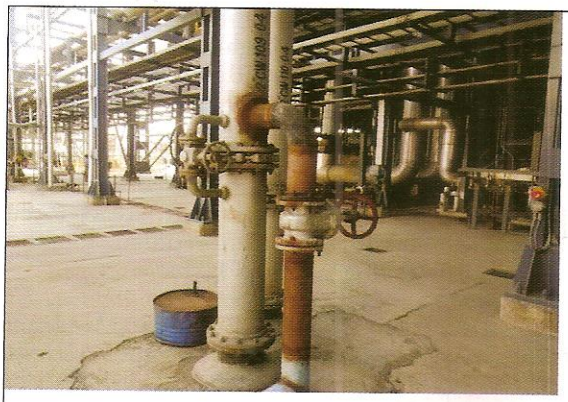

Figure 7 – Back flushing arrangement in -E-3312

Figure 8 – Back flushing arrangement in E-3405

The Scheme has already been implemented in Urea Plant of Vijaipur-I. Ammonia content in C-3 off gas has come down from 6-7% to less than 1% resulting in ammonia recovery of 900kg/h and corresponding net annual saving of Rs.16 lakhs. This has also resulted in significant reduction in NOx emission from CPP stacks. The Scheme shall shortly be implemented in Urea Plant of Vijaipur-II also.

♦ *Provision of on line backwashing system for Exchangers in Ammonia-II Plant*

With provision of the on line back flushing arrangement for **(E-3312,E-3403,E-3405 and E-3510A/B)** exchangers shown in **Figures 7 and 8,** it has been possible to decrease the exit process gas temperatures by and resultant reduction in energy consumption and debottlenecking for operation of plants at higher load.

In-house material was used for implementing this modification with improvement in heat transfer in the exchangers and thereby energy saving was achieved.

♦ *Modification in 11 E-21A/B Exchangers in parallel with separate Condensate/CW flow and separate isolation valves*

In urea plant of Vijaipur-I there are two shell and tube exchangers (each having one shell and two tube pass). Condensate flows in the shell side and cooling water in the tube side. After revamp of the plant, due to increase in additional equipment, the requirement of cold condensate in the system increased. Also at higher plant load E-21 condensate exit temperature was on higher side(more than 55° C during summer). A higher condensate temperature would have affected the plunger packing's of high pressure ammonia pumps. A study was undertaken to solve the problem without procurement of a new exchanger which would have cost to the tune of Rs 30-35 lakhs. In order to utilize the existing exchangers and get desired temperatures, the exchangers were put in parallel with separate cooling water as shown in **Figure**

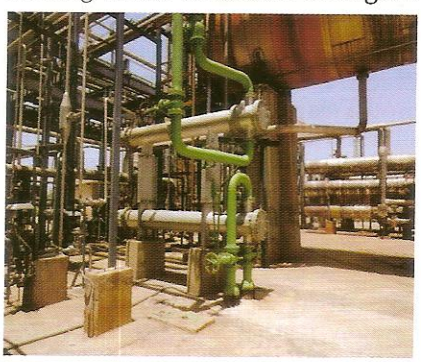

Figure 9 – E-21A/B in Separate CW flow

9 and condensate lines are successfully lined up. After implementation of the scheme, cooling the condensate to desired temperature (40°C) without procurement of a new exchanger was achieved.

♦ *Removal of interlock " HRU Supplementary Firing trip on GT not at operational speed" in Ammonia-II*

In Ammonia-II plant, process air compressor is driven by Gas Turbine (GT). Exhaust gases of gas turbine which normally remains at 475°C to 515°C (depending on load and ambient condition) is utilised in heat recovery unit to generate steam. Supplementary firing is also done in Heat Recovery Unit (HRU) with NG/ Naphtha.

Safe operation of GT is ensured through various trips interlocks included in Mark-V control system and that of HRU is ensured through various trip logics included in BMS & DCS. Trip logics include steam drum level low, steam temperature high, steam pressure high, fuel pressure high, trip of HRU circulation pumps. In addition to this, following trip interlocks have been provided:

HRU supplementary system firing trip was on "GT not at operational speed" (Operational speed is 80-105% of rated speed). Over speed trip of GT at 5307 rpm which is 104% of maximum continuous speed (5103 rpm). Electronic over speed trip provided at 5345 rpm.

Rated speed of Gas Turbine and Process Air Compressor are 4860 and 4911 rpm, respectively. Under extreme weather i.e. hot and humid conditions, power requirement of PAC increases significantly and has to be operated at a higher speed by 60-70 rpm to achieve the

same air flow.

During extreme weather conditions in order to avoid actuation of HRU SFS trip in case of fluctuation in GT speed. GT speed was limited at 5052 rpm (104% of the rated speed) instead of 105%. This has been done by limiting, Flow Indication and Control on process air to secondary reformer measured value (FIC27 MV) to 98%.

Imposition of the above interlock resulted in air shortfall to the tune of 2000Nm^3/h in hot and humid condition corresponding to 50 MTPD ammonia and corresponding 86 MPD during hot and humid conditions. The increase in speed limit without the removal of the interlock would not solve any purpose as any fluctuation in speed can again cause trip of supplementary firing. In view of this, the existing interlock "cut off of supplementary firing at GT not at operational speed" was to be removed and 32 FIC 27 limit to be increased from existing 98% to 100%.

The problem along with all pros and cons e.g. effect on furnace temperature etc. in case of removal of the interlock were thoroughly studied. It was concluded that there won't be any such problem after removal of the interlock. The same was implemented. Increase in ammonia production was achieved and corresponding urea production during hot and humid conditions.

♦ ***Provision of oil pressure equalization valve between oil filters of IAC-I and II***

In Ammonia-II plant, IAC-I and IAC-II lube oil filters not provided with ½ " equalization line. Before changeover of lube oil filters, it is a normal practice to equalize oil pressures of both the filters to remove air locking and slow charging of standby filter through ½" equalization line to avoid tripping of compressor due to drop in oil pressure during charging and changeover of filter the same was provided. The scheme had improved operating system and avoidance of trip of IACs.

♦ ***Cooling down Process gas inlet temperature to R-1204***

The process gas inlet to high temperature (HT) CO Shift Converter (R-1204) was running at higher temperature (365°C) against the required temperature (340 ~350°C). The new HT catalyst was charged in the year 2012-13. Higher inlet temperature of R-1204 reduces the catalyst life and increase the CO slip at converter outlet. In order to reduce the inlet temperature, a 14" bypass line across 12-HV-160 (R-1204 inlet MOV) was provided, where 14" Nitrogen line is connected with spectacle blinds at upstream and downstream of 12-HV-160. The line was connected with one TCV (12 TIC 55) to control the process gas temperature inlet to R-1204. The BFW quenching was taken from the closest point (2" BF121-01-F32S MP flushing water to F-1302 at 60 kg/cm^2).12 TIC 55 shall work on auto/manual and a separate trip group was provided to trip/close 12 TIC 55 on low temperature set at 330°C. A portion of the gas was diverted through this 14" bypass line by throttling 12 HV 160. The cooled bypass gas brings down the common HT Converter temperature to required 340-350°C. The scheme was implemented on temporary basis and after normalization; it has been kept out of operation.

♦ ***Replacement of K-3451 Lube Oil Discharge PRV***

Lube oil and seal oil lines of Ammonia Refrigeration Compressor (K-3451) was having significant vibration since quite a long time. Several attempts were made on this Pressure Reducing Valve (PRV) (345 PV-21) and extra strengthening of lube oil lines were also done to rectify the problem, but the problem continues and the vibrations was causing fluctuations continuously in oil pressure and sometimes these vibrations are found on higher side either due to resonance in the lines or due to PRV problem. In view of the above, the lube oil PRV (345 PV-21) was replaced with new PRV which can regulate the pressure smoothly. The scheme was implemented with investment of Rs. 2.28 Lakhs and achieved reduction in vibrations of seal oil and lube oil lines of ammonia refrigeration compressor, reducing chances of damage and malfunctioning of instrument.

♦ ***Modification to increase High Level Trip setting of Referigeration Compressor's Turbine TK-3451 (Re Condenser and TP-3801 B TTV)***

On 02.12.2012 cooling water circulation pump TP-3801 B tripped without any process fault. The turbine was restarted immediately but after loading the turbine, Refrigeration Compressor's Turbine (TK 3451) tripped on condenser high level leading to production loss. This type of event had appeared two years back. Since no process fault appeared on which the TP-3801 A can trip and hence only reason of tripping of TP-3801 B left is the malfunctioning of its Trip Throttle Valve (TTV). Almost similar type of tripping (without any process fault) of this turbine TP-3801 B observed on 04.08.2012 when MP-3801 C tripped.

In order to avoid such type of tripping of both the turbines, the existing TTV (Trip Throttle Valve) of TP – 3801 B (Amm-2 Cooling Water Circulation Pump) was overhauled and a delay of 10 seconds incorporated in the condenser high level trip (34 LAXH-54) to take care of sudden change in condenser level due to any variation in CW flow and unwanted tripping of Refrigeration Compressor.

♦ ***Replacement of existing 2" GV Process Condensate line to 3" in Ammonia Plant of Vijaipur-II***

Earlier problem was being faced to transfer process condensate from Ammonia-II GV Section Condensate Separators (B-3306 to B-3307) during normal operation of plant because of line size limitation. This aspect was causing frequent local draining and wastage of condensate. In

order to prevent wastage and for smooth operation, the 2"dia line was replaced with 3"dia line along with three no. of isolation valves .

♦ *Change in GV Section Trip Logic of Ammonia Plant of Vijaipur-II*

Trip interlocks in GV section in Ammonia II Plant (IS 4 & IS 5) are the trip groups related to Tripping of GV section. IS 4 leads to tripping of complete GV section, while in case of IS 5 GV lean and Semi lean pumps continue to run. 33 FIC 22 is a valve which is located in the discharge line of semi lean pumps (P 3301 A/B/C) and allows transfer of semi lean solution to GV absorber. In the earlier set up tripping of IS 5 led to closure of 33 FIC 22. As the pump kept on running on tripping of IS 5, entire GV solution had to be recycled through MRV, causing heavy vibration in minimum circulation line and abnormal sound was noticed in the pump. In view of the above, considering the safety of the machine and the system, the proposal was made to change the existing logic of closing of 33 FIC 22 on IS 5 to IS 4. Closure of 33 FIC 22 is a must to avoid any back flow of fluid from absorber. The modification improved plant safety system and prevent tripping of plant .

♦ *Relocation of ΔP measurement tapping of Suction Air Filter of Process Air Compressor (K-3421) of Ammonia-II Plant*

Gas Turbine (GT-3461) and Process Air Compressor (K-3421) of Ammonia-II plant have been provided with single stage self cleaning type Air Filtration system (of M/s Donaldson India, Gurgaon) which are self-cleaned by reverse flow of pulse of compressed air in their suction.

There are 384 and 96 numbers of filter elements respectively for Gas Turbine (GT) and Process Air Compressor (PAC) Design flow through the filters for GT & PAC is 4619 Nm^3/Min and 1500Nm^3/min respectively.

Initial clean air flow resistance (ΔP) of both the filters is 25mm of water column. The same is always observed in case of GT. Inspite of installing filters supplied by OEM, ΔP of 40-45mm used to be observed in PAC since commissioning whenever new filters are being installed. New synthetic filters supplied by OEM, installed on 10/11/2011 also gave ΔP of 40-45mm water column.

Process Air Compressor suction air filter ΔP measurement system is connected to PAC trip on high ΔP

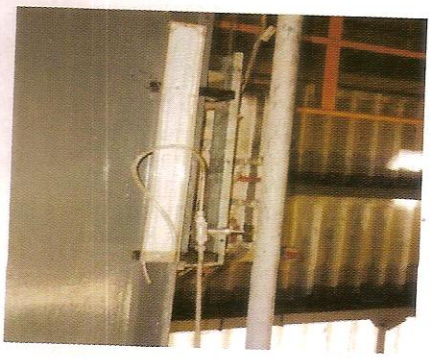

Figure 10 – ΔP transmitter

Figure 11 – ΔP transmitter

at 200mm of water column shown in **Figure 10 and 11**. In view of that an additional ΔP measurement system to meet specified ΔP of suction air filters is provided. The modification carried out for system improvement.

♦ *Modification in DM Water Pumps P-4511 A/B to meet additional requirement of DMW in Ammonia-II after revamp*

In Ammonia-II plant there are two DMW pumps (P-4511 A/B) to supply DMW to De-aerator (B-3601). Pump P-4511A is driven by back pressure steam turbine, whereas P-4511B is driven by electric motor. Present specification and post revamp requirement of each of the pumps are specified below:

Considering the continuous requirement of 416 M^3 and to maintain a steady flow of DMW during normal operation and during upset in the plant, in the post revamp case, the following proposal has been made. The rated capacity (which is considered as 10% more than normal flow) may be increased to 460M^3/Hr at 70M differential head. Present motor and turbine rated power is 110kW & 106 kW respectively, whereas the post revamp power requirement for normal capacity of 460 M^3 flow will be 116 kW. Hence, motor and turbine are also to be evaluated for the new power requirement. Replacement of the existing impellers of 460 mmϕ with new impellers of 504mmϕ by procuring the same from OEM. Replacement of existing motor of 110 kW rating with a new motor of 150 kW rating. The Scheme was implemented with total investment of Rs. 21 lakhs. Thereby debottlenecking and energy saving by avoiding SL venting.

♦ *Shifting of Anti-surge controllers of CO_2 and N_2 Blowers to CS-3000 DCS System in Ammonia-II Plant*

In Ammonia-II plant CO_2 and N_2 blowers are installed for increasing the pressure of CO_2 and N_2 gas respectively. Both CO_2 & N_2 blowers are supplied by M/s DemagDelaval Turbo-Machinery having dedicated anti-surge controller of make Hartman and Brown. In view of the above, the existing dedicated anti surge controllers of CO_2 and N_2 blowers are shifted in CS-3000 DCS system by keeping the existing control philosophy and same process parameters. The scheme had achieved nominal energy saving.

♦ *Provision of overflow line from New V-4 Tank (Urea dissolving Tank) to old V-4 Tank*

There are two number of Urea Dissolving Tanks (V-4) in Urea-I

plant for dissolving and recovery of spilled urea from Bagging plant. The dissolved urea solution is transferred from V-4 to V-5 Tank (Urea Recovery Tank) by pumping and then recovering the same into system. The new V-4 tank used to overflow frequently due to choking of the filters. In order to avoid overflow, an overflow line from new V-4 tank to old V-4 tank was provided. Urea solution now can be transferred from the new V-4 tank to old V-4 tank by gravity at the time of overflow of new V-4 tank. The old V-4 tank has already a Level Transmitter with an indication in CCR which helps in taking timely action and prevent any overflow. The scheme was implemented with nominal investment of Rs.5000. This modification will prevent overflow urea solution from the new V-4 tank and contamination of floor washing pit and consequent improvement in effluent quality..

♦ ***Stopping of Cooling Tower fan motor one each in Urea-I and II***

In Urea Plant, Cooling Water inlet temperature is coming down below 23°C in winter season which is not desirable for Carbamate Condenser and in Vacuum section of the plant due to chocking problem in condensers because of urea. To avoid this situation, Auto ON/OFF switch is provided at Fan C that stops the fan below 23°C and starts again on 26°C. The scheme had achieved electricity saving.

♦ ***Provision of 3" and 4" stage water cooled inter stage cooler instead of Air cooled inter stage cooler for Passivation Air Compressors in Urea-II Plant***

There are four numbers of Passivation Air Compressors (reciprocating type) namely 31/41 K-3 A/B of M/s BAUR Compressors provided in Urea-II plant for supplying high pressure compressed air at 145kg/cm² to the Urea Stripper 31/41 E-1 for the passivation of 2RE69 liner.

The machine is with four stages of pressure 2.7/11.6/57/150 bar including air cooled interstage coolers with separators.

For better performance of inter stage coolers, fabrication and installation of water cooled inter stage coolers was carried out in 31 K-3 A/B and 41 K-3A/B as shown in **Figure 12**.

The scheme had improved efficiency of interstage coolers.

Figure 12 – Water cooled inter stage coolers

♦ ***Provision of vent line for venting ammonia from Vacuum breaker of 31/41-V-10 in upset conditions***

During plant upsets or during startup, the high concentration of ammonia in the process fluid increases the pressure in the system and ammonia vapors started coming from V-10 top vacuum breaker. One hollow pipe was provided over the V-10 vacuum breaker to guide ammonia vapors coming from it to the atmosphere at 3rd floor height as shown in **Figure 13**, so that people working in the synthesis section could not get trapped in it. Benefit achieved is safety of the people.

♦ ***Use of a surplus intercooler (31/41 E-27) as alternative to Existing one (31 E-21A/B) to meet the increased heat load***

In Urea-II plant 31-E-21A/B has been provided to cool the hot condensate of 31-V-2 from 110°C to 40° before use in pre-concentrator vacuum scrubber and as seal flushing water for Carbamate pumps. Earlier requirement of cold condensate was 9m³. After Capacity Enhancement Project (CEP) the requirement of cold condensate increased to 22m³ (increase of 13m³). At higher condensate flow, the heat duty shall be 1.4 GCal/hr which is more than double the design value for existing exchanger.

In CEP of Urea-II plants, interstage coolers were replaced. The third stage intercooler 31 E-27 (CW on shell side) of which the tube side design pressure of 115 kg/cm² and tube side inlet/outlet temperature of 230/50°C which was rendered surplus seems suitable to meet the requirement in place of existing 31-E-21 A/B. Following modifications was carried out for using 31-E-27 in place of 31-E-21A/B as shown in **Figure 14**.

To meet the requirement of higher cooling water flow existing CW inlet/ outlet lines of E-21 A/B lines

Figure 13 - 8" header for venting Ammonia from V-10

Figure 13 – Spare E-27 used in place ofE-21A/B

were replaced from 6" to 10" and headers may be replaced from 10" to 12".

Inlet and outlet condensate headers were changed from 2" to 3" lines. Separate foundation was constructed for 31 stream CO_2 compressor 3rd inter-stage cooler (E-27) near 31 stream condensate coolers in Urea-II plant (31-E-21 A/B). A 10" tapping for CW inlet and outlet headers with I/V from 12" common header was taken. Tapping for condensate inlet and outlet line was taken. The capacity of the exchanger is more than required heat duty, therefore 10-15% of the tubes may be plugged which would also result in increase in condensate velocity in tubes. The scheme was implemented with total Investment of Rs.5.55 Lakhs. Financial saving of Rs 35 lakhs was achieved by using in-house surplus exchanger and avoidance of procurement of a new exchanger.

♦ *Installation of New Neem Oil Tank and additional requirement for Neem coating of total product*

Earlier neem coating system facility was provided only for Vijaipur-I urea and old silo recovery material at conveyor belts in bagging plant (ET-7A & ET-7B) conveyor drive end. There was no provision for neem coating of Vijaipur-II urea. In this way, maximum 50% of total production could be neem coated. In order to facilitate 100% neem coating following was required - A new tank for storage of additional neem oil required for neem coating. Provision of oil spray for material at ET-31 drive end to facilitate neem coating of urea produced from Vijaipur-II and urea reclaimed from new silo, Replacement of ET-10 2A/B and ET-31 d/s belts with oil resistant belts, Provisions of PCVs with manual operation philosophy for control of neem oil spray pressure, Insulation of both the oil tanks and lines to prevent heat loss and thereby maintain proper temperature and viscosity of neem oil. Procurement of another spray nozzle for spray of neem oil on urea material on ET-31 (spare nozzle available), Provision of an additional transfer pump of 50 LPM and 50 m head with 2.2 kW motor. Replacement of both the neem oil spray pumps with new ones as a long term measure. The scheme was implemented with total investment of Rs. 20 lakhs. Now bagging plant is capable of 100% neem coating of urea.

♦ *Use of One chlorinator in Pre-treatment Plant (PTP) Plant (CP&O)*

In PTP, there are two numbers of chlorinators for dosing chlorine for treatment of raw water as well as disinfection of drinking water. The post chlorinator is developing leakages frequently and is safety hazard being chlorine a very toxic gas and the repair of the same becomes a tedious job because of non-availability of parts from OEM.

In view of the above, and to use part of chlorinated water generated from pre-chlorinator for disinfection of drinking water, one small holding (Manifold) MS/ CS rubber lined vessel was installed to receive chlorinated water from pre-chlorinator and the vessel was connected with an injection line at chlorine contact vessel and 1" line was tapped off from the vessel with an isolation valve to connect with PVC or rubber line to take chlorinated water to drinking water as shown in **Figure 15**. This scheme had reduced risk of chlorine leakage and maintenance cost of post chlorination system.

Figure 15 – Modification in pre-Chlorinator

♦ *Provision of additional high pressure pump in Waste Water Pond-A for spraying*

The ammonical waste water generated from plants are stored in Pond-A. Its quantity varies during startup, shutdown and upset conditions of the plant. It is being treated and transferred to Pond-B for use in horticulture purpose. For reducing the ammonical content in Pond-A sprayers are used as shown in **Figure 16**. It is

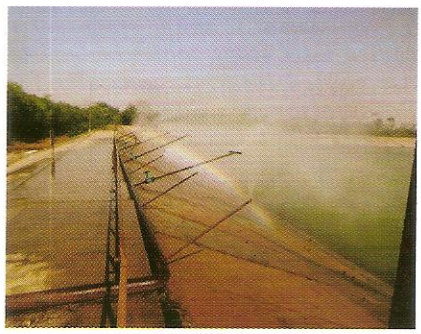

Figure 16 – Spraying System

required to have an additional pump of around 50m³/hr of 6-7kg/ cm² capacity and a separator system with nozzles in north side

of Pond-A at pump suction pit.

One pump from Urea-II, declared surplus after CEP, was checked for adequacy for use for the said purpose and it was found adequate and installed. Also, special spray nozzles were installed. The scheme is working alright and has reduced ammonia content significantly during summer and achieved environment protection.

♦ ***Use of hot condensate as motive fluid for regeneration of Strong base anion and Weak base anion (SBA/ WBA-1A/1B/1C) in DM Plant***

In DM pant, regeneration of strong base anion (SBA) resin is carried out with hot caustic solution (16%) to remove the residual silica from the resin bed. The degassed water heated up to 50°C with the help of LP steam to make the regenerant of desired concentration. By using hot condensate coming from Urea-I for regeneration of SBA will save the use of steam which is being consumed for heating the degassed water. By implementing this scheme the steam saved to the tune of 9Te. per SBA regeneration.

♦ ***Switch over of treatment of water from Alum to Poly Aluminum Chloride in Pretreatment Plant***

At NFL, Vijaipur, for treatment of raw water alum was being used as a coagulant and lime for pH correction (addition of alum reduces pH of water which further increased to 7.5-7.8 for better flocculation with the help of lime).

In view of better treatment with Poly Aluminium Chloride (high basicity liquid), use of PAC has been started in place of Ferric Alum from April 2010 as a coagulant in DM stream on trail basis. It is noticed that the use of PAC in DM stream is beneficial and there is marginal saving in producing 1000M^3 filtered water from PAC. The scheme was implemented with total investment of Rs. 6.25 lakhs with saving in 1000M^3 filtered water from PAC (Rs. 2.98 lakhs) with payback period of 2.1 years.

♦ ***Provision of field controlled Pressure Control Valve (PCV) in the Sanitary Water Pump discharge header for controlling sanitary water pressure/flow to township as well as factory***

This modification was implemented to reduction in water loss due to leakages.

♦ ***Relocation of surplus gas tapping from its existing location of Methanator outlet to Benfield Gas Absorber (F-1302) outlet***

This modification had achieved energy saving because of increase in surplus gas temperature from 35°C to 70°C.

♦ ***Modification of liquid ammonia line from Distillation Column (F-3521) to Flash Vessel (B-3503)***

Earlier cold ammonia from recovery section was mixed with hot ammonia and then sent to Atmospheric Ammonia Storage Tank at atmospheric pressure and -33 ° C. In view of mixing of cold and hot ammonia, the temperature of ammonia to storage tank used to increase and caused increase in frequency of ammonia compressors in Ammonia Storage Tank Section. Also, sometimes the Ammonia Storage Tank's vent used to open due to high temperature and pressure.

The system was modified and now the hot ammonia is flashed in a flash vessel before mixing with cold ammonia. This has resulted in energy saving due to lower operation hours of ammonia compressors and avoiding ammonia loss.

♦ **Provision of connection from 11/ 21P-1A/B Suction strainer drain line to close drain system.**

In Urea-1 plant , whenever P-1 A/B pumps are required to be depressurized, drained for maintenance activity, pump suction dampener PSV bypass is opened for depressurization by evaporating ammonia through bypass valve as there is no drain available in suction header of P-1A/B pumps. By connecting suction strainer drain to close drain (CD), liquid ammonia in suction header can be drained in CD and then vapors are depressurized through Pressure Safety Valve (PSV) bypass. The scheme improved environment protection and achieved recovery of ammonia through close drain.

CONCLUSION

The Modification Schemes, if implemented with care and proper study including HAZOP, can result in significant improvement in the system w.r.t. Plant safety, operational flexibility, saving in energy and natural resources. ■