Nagarjuna Fertilizers and Chemicals Limited

(i) Unit Profile:

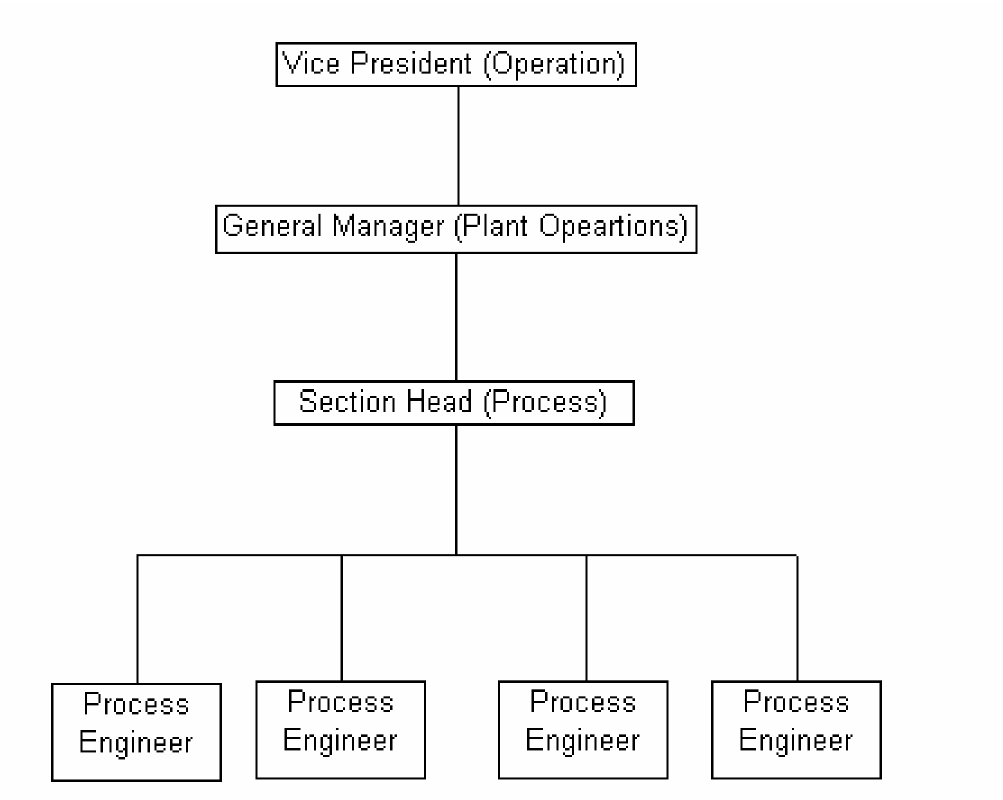
Nagarjuna Fertilizers and Chemicals Limited operates large modern integrated Ammonia-Urea complex laid out in two streams each with Ammonia and Urea plants. The manufacturing facilities are located at Kakinada in the East-Coast of India in the state of Andhra Pradesh. Unit-I, which was commissioned in Aug 1992 comprises a 900 MTPD Ammonia plant and matching 1500 MTPD Urea plant and is fully based on Natural Gas both as feed and fuel. The Ammonia plant is based on Haldor Topsoe's steam reformation process and the Urea plant on Snamprogetti's Ammonia self-stripping process.

NFCL is proud to be accredited with ISO 9001, ISO 14001 & OHSAS 18001. Also it was awarded with the coveted "5 star rating" from the British Safety Council during Jan 2005 for the excellent safety standards maintained.

(ii) Energy Consumption:
Include information on total energy consumption (i.e., coal, oil, gas, electricity and money value). Information on energy consumption in terms of percentage of manufacturing cost should also be presented. Also, it should highlight the specific energy consumption for the period 2002-03, 2003-04 & 2004-05. Good Computer Graphic Presentation related to Specific Energy Consumption may also be incorporated.

(iii) Energy Conservation commitment, policy and organization set up

Organizational Setup:



Energy conservation policy:

The specific energy consumption reduction by 1% every year for the next five years.

(iv) Energy conservation achievements

(Include one paragraph write up on each major energy conservation project implemented during the year 2004-05 only.

a. The leakage of the HP stripper in urea plant was attended which avoided steam and ammonia loss. Though this project resulted in down time of the plant, gave a net savings of 27218 Gcals / yr and monitory befit of 93.8 Lakhs per year.

b. Control valve replacement in the Methanation inlet from globe type to ball type gave a pressure drop reduction of 0.65 Ksc. This resulted in an energy savings of 11154 Gcals / yr and a monitory benefit of 38 Lakhs per year.

c. Secondary reformer catalyst top layer of the catalyst scooping operation was carried out which resulted in a pressure drop reduction of 0.5 Ksc. This resulted in an energy savings of 8580 Gcals / yr and a monitory benefit of 29 Lakhs per year.

d. The methanator feed / effluent heat exchanger was cleaned thoroughly which resulted in a pressure drop reduction of 0.9 Ksc, This resulted in as energy savings of 15444 Gcals /yr and monitory benefit of 53 Lakhs per year.

e. The process gas inlet to the reboiler of GV section temperature was reduced by 2° C so as to recover more heat in the BFW circuit without compromising the performance of the CO_2 removal section. This resulted in the energy savings of 8846 Gcals / yr and a monitory gain of 30.5 Lakhs per year.

f. The other periodical survey that help us to keep our energy consumption in stringent control are steam trap performance, Safety Valves and Vent control Valves Passing Checks Insulation Survey, Refractory Lined Furnaces Skin Temperature and Thermography Survey, Stack Flue Gas Analysis for Excess air control and Pressure drop survey across major lines and equipments

(v) Energy conservation plans and targets

The main target set to be is the implementation of the energy audit findings that was conducted between Aug 2004 and Jan 2005. Projects, which don't require investment, have been already implemented and the rest are being done in a phased manner depending upon the quantum of investment required. The projects identified by the team of energy audit have been mentioned in the table under Question number 18.

(vi) Environment and safety

Environmental protection is an avowed corporate philosophy at Nagarjuna.

Nagarjuna Group's commitment towards Environmental Management is widely appreciated and prestigious awards were conferred:

- Environmental Protection Award' in Nitrogenous Fertilizer plants category for the year **2001-02** from Fertilizer Association of India, New Delhi.

- Cleaner Production Award for Good Practices for the year **2003-04"** from Andhra Pradesh Pollution Control Board, Hyderabad.

The Kakinada Plant is built on the principle of zero effluent discharge and is totally Eco-friendly. The complex adopted the strategy of:

- Zero discharge of liquid effluents outside factory premises
- Ambient Air Quality Monitoring and control well within NFCL's standard, which are more stringent than Pollution control board's limit.
- Development of Green Belt
- To reduce water consumption and effluent generation, a target of 2% reduction every year is being followed.

In consonance with this, an integrated Environmental Management Plan (EMP) was envisioned at the conceptualization stage of the project and, as a result, a number of environmental control and monitoring measures have been incorporated in the basic design itself to ensure strict adherence to International standards.

An Environmental Impact Assessment (EIA) was made at the pre-project stage based on which the EMP was developed incorporating all the findings of the EIA. Utmost care was taken to maximize the recycle and reuse of various waste waters generated within the complex.

A number of new technological features implemented in this complex were used for the first time in India. Some of the major pollution control features installed in the process plants are disc oil separators for removal of Oil & Grease, use of low NO_x emission and high efficiency burners in the reformers, dedusting system for prilling towers in urea plants, dust extraction system in the product handling and bagging plants, non-chromatic cooling water treatment system with chemicals that easily biodegrade, facilities to segregate process, storm/rain water and oily water to enable treatment of pollutants more effectively, impervious lining to all pits and tanks to avoid seepage of any effluent to the ground water system, flare stacks with continuous and dual firing facility etc.

The company has been accredited with ISO 14001 certification (an Environmental Management System) from M/s BVQI, Netherlands effective from May 2000.

The safety and health of all employees is of paramount concern in NFCL. The management is fully committed to maintain the highest standards of safety and health in the work place. The emphasis is on sound safety management systems and practices. The employee participation is ensured by the Departmental Safety Committees where matters concerning safety are dealt with promptly. The company has won a number of certificates and recognitions from BSC (U.K), NSC (USA) and ROSPA (U.K) for its safety performance. The company has been accredited with OHSAS 18001 certification from M/s BVQI effective since April 2001.

PROCESS DESCRIPTION

AMMONIA PROCESS

The feed stock natural gas is desulphurised by conversion of stable organic sulphur compounds into Hydrogen Sulphide in presence of Nickel Molybdenum catalyst followed by adsorption of Hydrogen Sulphide on Zinc Oxide bed. The desulphurised natural gas is mixed with super heated steam to give steam to Carbon ratio of 3.3:1, preheated and fed to the catalyst tubes in Primary Reformer. The Primary Reformer is a side-fired furnace with radiant burners. The natural gas, which is predominantly methane, undergoes following reactions producing Hydrogen and Carbon Oxides:

$$CH_4 + H_2O \text{ ------------- } 3\ H_2 + CO - \text{heat}$$

$$CO + H_2O \text{ ------------- } CO_2 + H_2 + \text{heat}$$

The process gas from the tubes is gathered by a collector system and sent to the Secondary Reformer.

The Secondary Reformer is a refractory lined vessel containing Nickel catalyst. Air from atmosphere comes in contact with the process gas from Primary Reformer. Combustion of some part of Hydrogen and Methane occurs consuming the total oxygen in the air and the temperature rises to about 1300 deg. C. This supplies the heat needed for completion of the endothermic reaction in the catalyst bed. Nitrogen needed for ammonia synthesis gets introduced in to the system in the Secondary Reformer through the process air. The gas leaving Secondary Reformer contains residual Methane of 0.6%. The exit gas from Secondary Reformer is cooled to about 380 deg. C in the Waste Heat Boiler where high-pressure steam is generated.

The carbon monoxide formed in the reforming step is converted to CO_2 by water gas shift reaction in two stages, namely, high temperature shift conversion and low temperature shift conversion. The HT shift reaction takes place in presence of iron oxide chromium oxide catalyst and LT shift reaction takes place in presence of copper oxide zinc oxide catalyst. The shift conversion reaction being exothermic, steam is produced by heat recovery.

The reaction-taking place in the shift conversion can be represented as:

$$CO + H_2O \text{ --------- } CO_2 + H_2 + \text{heat}$$

The process gas leaving the CO conversion step contains in addition to Hydrogen and Nitrogen, large quantity of CO_2 and small quantities of CO, Argon and Methane. The CO2 present in the process gas is removed in the CO_2 removal section using Giammarco Vetrocoke process.

Here, CO_2 absorbed in potassium Carbonate solution is regenerated by reducing the pressure and addition of heat in two stage regenerators. The regenerated solution is pumped back to the absorber. Thus, the system operates in closed circulation. The CO_2 gas stripped from the solution in the regenerators is cooled and sent to Urea plant.

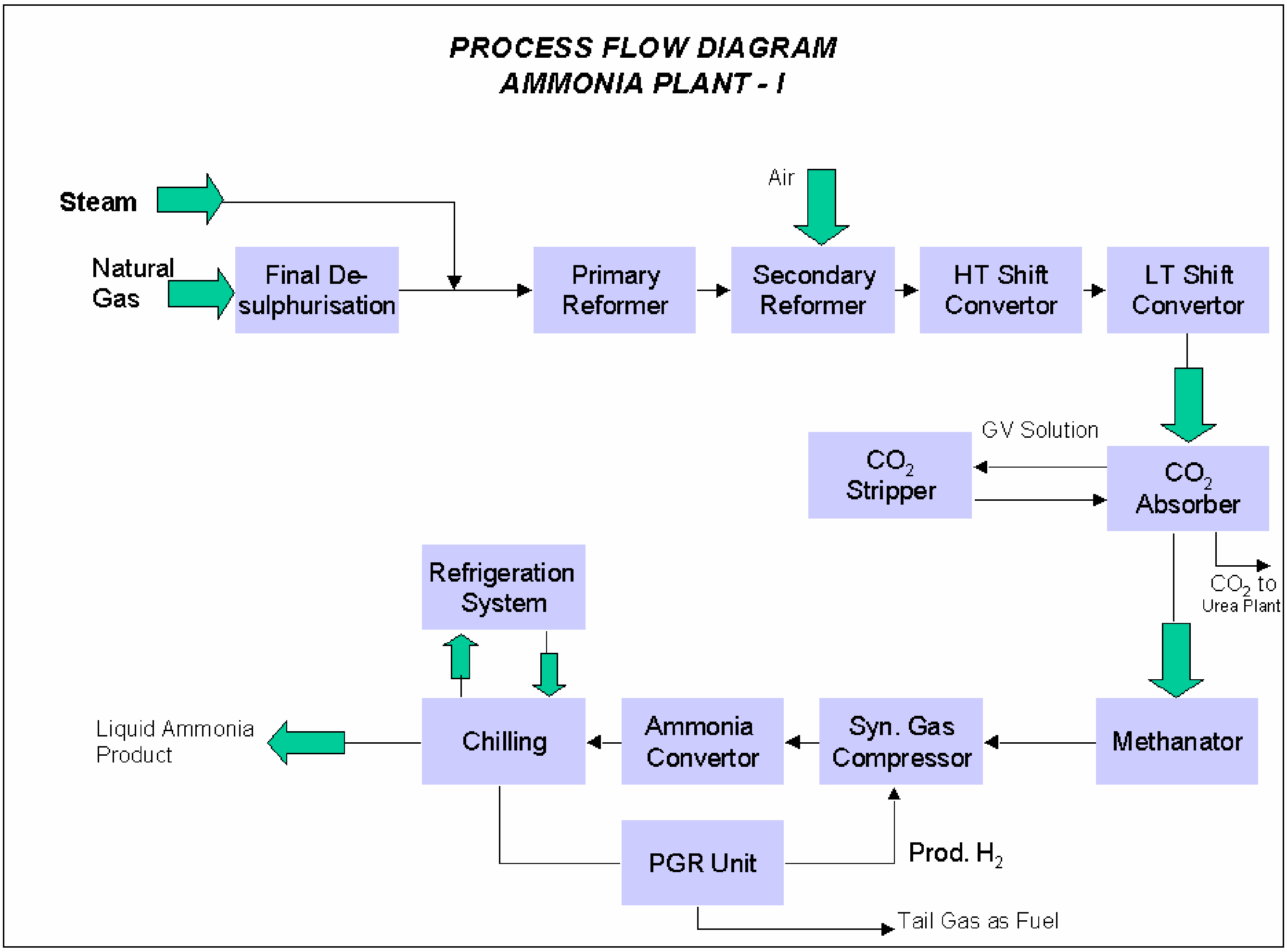
The process gas exit absorber now contains only traces of CO and CO_2. Since carbon oxides act as poison to the ammonia synthesis catalyst, the residual carbon oxides present in the process gas are converted into methane in a methanator reactor containing nickel catalyst. This step is the reverse of reforming reaction and consumes a small amount of hydrogen.

The methanator exit gas after cooling and removal of condensate is the synthesis gas with some interests. This gas is compressed from 24 Kg/Cm^{2}g to 134 Kg/Cm^{2}g in a centrifugal syn gas compressor. Also, there is a recirculation stage in the compressor where the recycle of unconverted gas along with the compressed make up gas are further compressed to about 142 Kg/Cm^{2}g. This gas after pre-heating is admitted to ammonia synthesis converter containing promoted iron catalyst, where Hydrogen and Nitrogen combine to form ammonia with evolution of heat. The ammonia synthesis reaction is:

$$N_2 + 3\ H_2 \text{ ------------- } 2\ NH_3 + \text{heat}$$

The gas from the converter is cooled in a series of heat exchangers including a Waste Heat Boiler. The condensed ammonia is separated and the uncondensed gases are recirculated back to the converter via the recirculator compressor. The product ammonia is cooled to a temperature of -33 deg. C by means of ammonia refrigeration system. The inerts level in the synthesis loop is kept low by taking an inerts purge and sending the same to the purge gas recovery unit where ammonia and Hydrogen are recovered and the remaining off gas is used as fuel. The product ammonia is pumped to the ammonia storage tanks or directly to Urea Plant.

Process Flow Diagram for Ammonia Plant:



UREA PLANT

The production of Urea requires ammonia and CO_2 as the inputs, both of which are available from Ammonia plant. The CO_2 from ammonia plant is compressed to about 160 Kg/CM^2 and sent to th Urea Reactor. Liquid Ammonia is pumped using high-pressure reactor feed pump and along with recycle carbamate enters into Urea Reactor. Urea Reactor operates at about 156 Kg/CM^2 and 188 deg. C.

Following reactions take place in the Urea Reactor:

$2\ NH_3 + CO_2$ -------- NH_2COONH_4 (Ammonium Carbamate) + heat

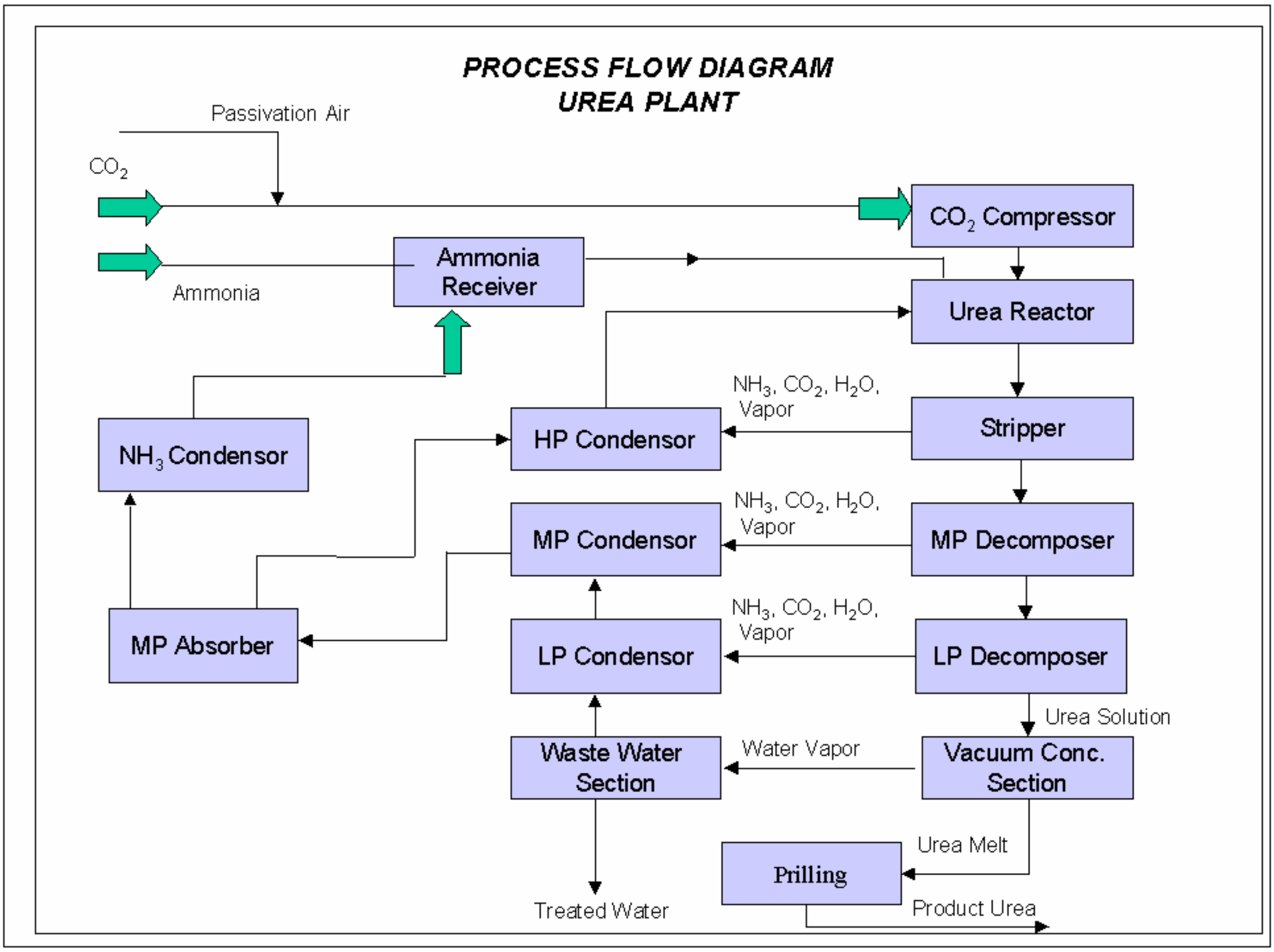
NH_2COONH_4 ----- CO $(NH_2)_2 + H_2O$ – heat (Urea)

The product stream from the Urea Reactor contains in addition to Urea, large quantity of unconverted ammonia, CO_2 and water. The ammonium carbamate in the product stream is recovered in three stages viz., high pressure stage, medium pressure stage and low pressure stage by decomposing the carbamate into ammonia and CO_2, separating the gases from the liquid product stream and recondensing the gases back to carbamate solution which is recycled back to the Urea Synthesis Reactor. In this process, the product stream becomes richer and richer in the urea content. In the high-pressure section, separation of Ammonia and CO_2 in the falling film of liquid in the tubes is stripped by ammonia vapour. Medium pressure steam supplies the required heat.

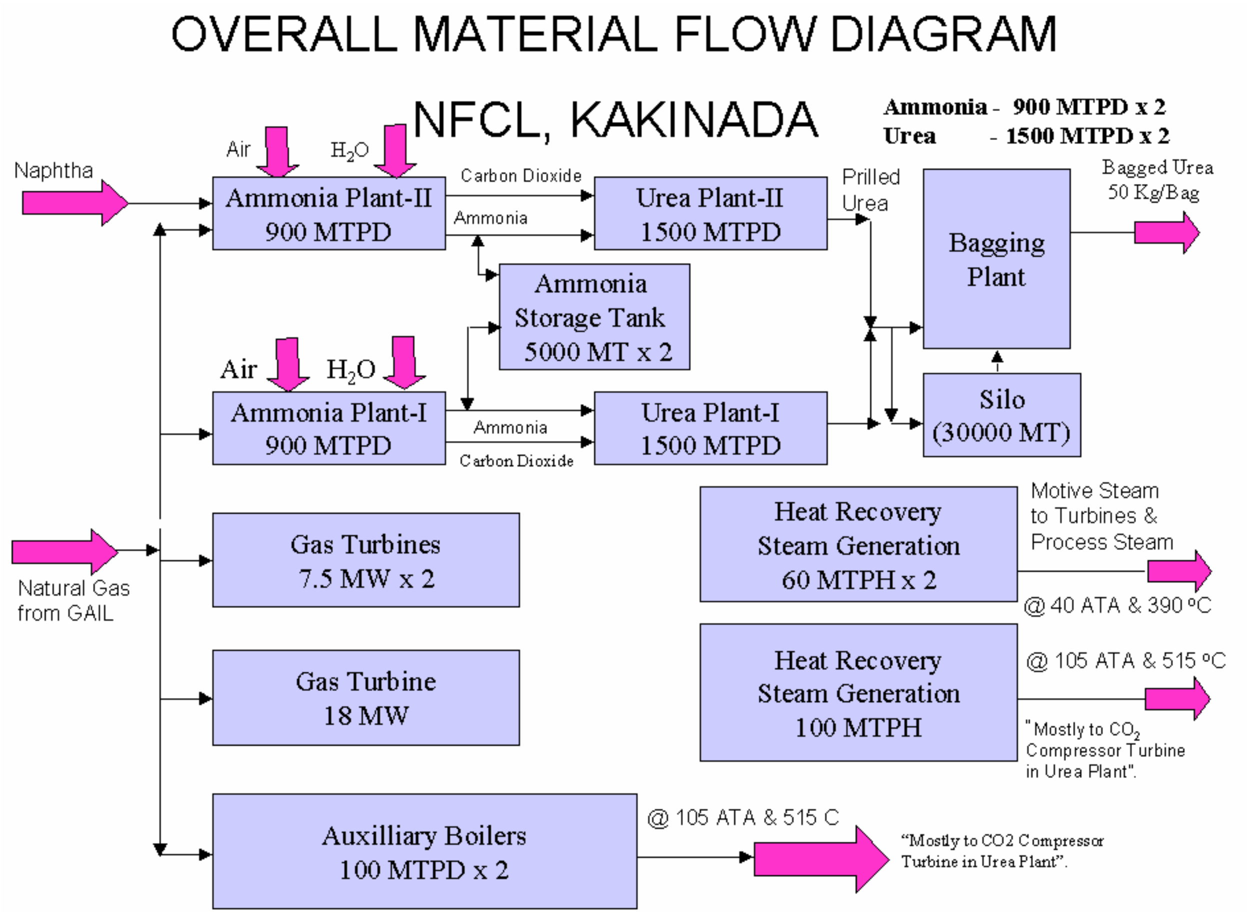
As the Urea Reactor operates with excess ammonia, the excess ammonia is recovered in ammonia condenser. The product stream leaving the low-pressure section contains 70% Urea. This is further concentrated in the vacuum concentrators to get 99.8% Urea melt. This molten Urea is pumped to the top of urea prilling tower

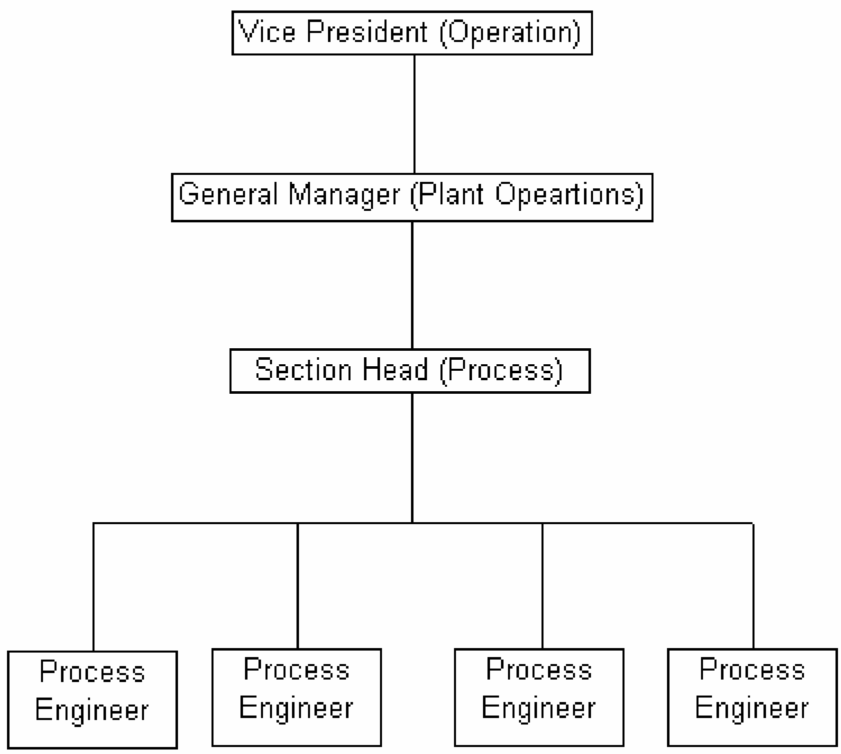
and fed into a prilling bucket. The prilling tower of 22-M diameter and 75 M free fall height operates under natural draft. The Urea Prills from the bottom of the prilling tower are transported through mechanized belt conveyor system into urea storage silo or directly to urea bagging plant. The bagged urea is dispatched by rail wagons/road trucks.

Process Flow Diagram for Urea Plant:



Schematic Diagram showing the production process of the entire complex:





a) Give salient features of EC Cell's constitution, functions, amount of finances available, achievements, future plans, strategy followed to implement energy conservation programs and policies, etc.

Energy Cell Constitution & Functions:

The Energy Conservation Team is headed by the Section Head (Process) and assisted by four Process Engineers. The ideas of various plant personnel are received through their respective Section Heads. Meetings are regularly held at section head level to identify key areas where energy can be optimized. Brainstorming sessions are held collectively to find an efficient methodology of operation and also energy improvement suggestions given by plant personnel are analyzed for their cost benefit, HAZOP, environmental and safety aspects. Based on the merits of the suggestion a Plant Modification Authorization (PMA) is raised and forwarded to Vice President (Operation) for authorization and implementation. The necessary specifications / P & ID are developed by Process Engineering Department.

Finance Availability:

Every year budget is allocated for PMA's. There are no financial constraints for implementing the Energy Conservation schemes identified. In case for a PMA if the investment exceeds the total budget a special approval is sought for its implementation.

Future plans for 2005-06:

S. No.	Project Description	Investment Planned (Rs. Crores)
1.	Advanced Process Control (APC) in Ammonia-I	1.0
2.	Additional heat recovery from reformer flue gas in Ammonia-I	1.0
3.	Steam injection in Gas Turbine for capacity augmentation and performance improvement	3.0
4.	Additional heat recovery from HRSG (C)	4.0
	Total	**9.0**

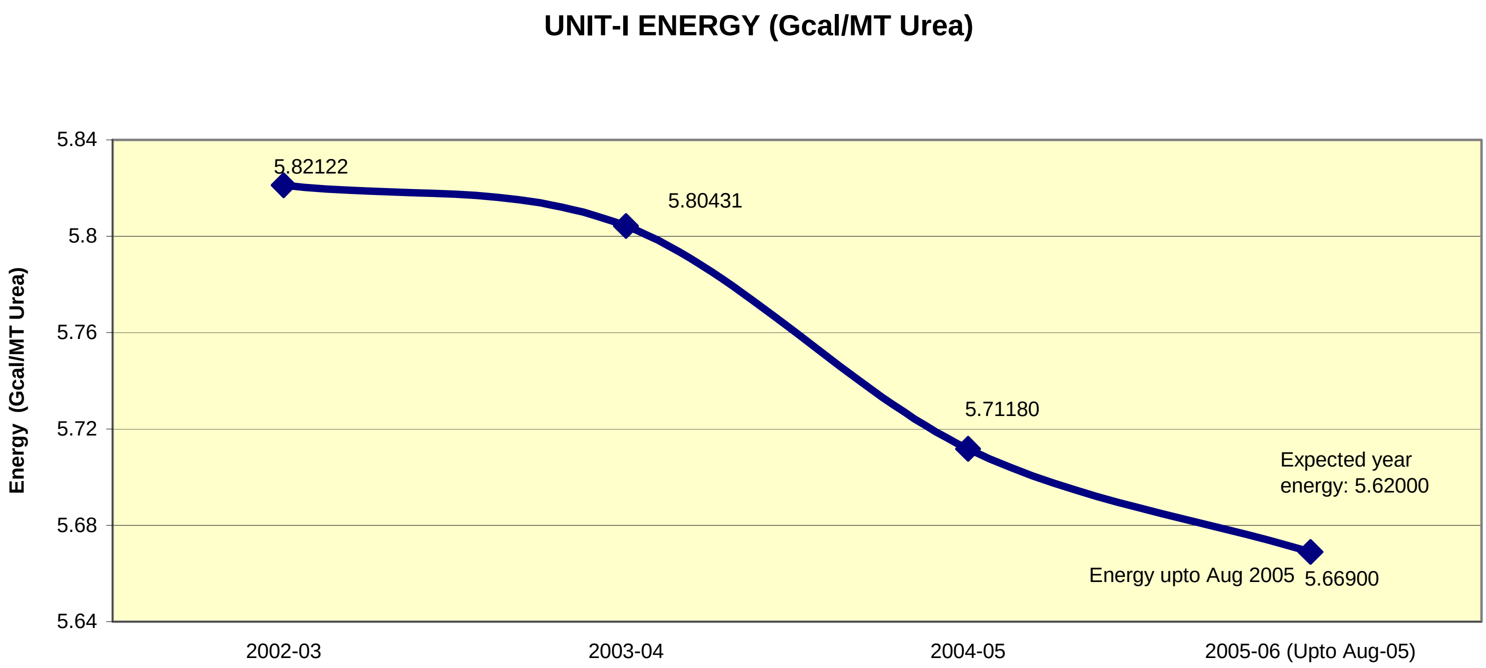
The specific energy consumption reduction on implementing the above major projects is expected to be around 1 %

Other miscellaneous projects are listed under Q. No. 18.

Energy Conservation Strategy:

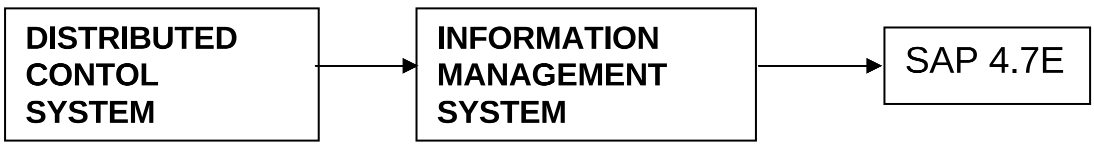
The Energy Conservation Team monitors the performance of individual plants, Equipments, Rotary machines, Reactors etc. Normally the performance of previous year is analyzed and future targets for specific energy consumption is fixed in annual production plan and strategies are worked out to attain the target.

By concerted effort of the cell, the specific energy consumption has been brought down from 5.82122 (Gcal / MT of Urea) during the year 2002-03 to 5.7118 Gcal / MT of Urea during the year 2004-05. The following graph depicts the energy performance during the past and in the present:



b) Does your unit have energy accounting and monitoring procedures and system in place. Which department is responsible to maintain such records - EC cell or any other?

We have an extensive Information Management System (IMS) in the complex. The plant information relating to all critical parameters are generated in the form of Hourly, Shift and Day Averages. Process information can be sought on-line through intranet throughout the complex.



Information from IMS is directly uploaded to the Enterprise Resource Planning (ERP) package SAP 4.7E (Upgraded version from SAP R/3). Specific Energies of various plants is calculated immediately by in-built programs. Energy reports for any period can be retrieved from SAP. This helps in an elaborate analysis on Energy consumption for various periods and to take better decision. Process Engineering section is responsible for accounting and monitoring Energy.

The various Energy Reports generated are referred by plant operating / maintenance personnel, General Manager (Plant Operations) & Vice President (Operations) and thus control over energy consumption is exercised.

e) Has your unit/organisation declared its `Energy Management Policy'? If yes, please attach a copy of the same.

Energy Management Policy:

The specific energy consumption reduction by 1% every year for the next five years.

Project for the Year 2004 to 2005:

Pressure drop reduction in Ammonia plant:

(i) Brief about the project:

It is a well-known fact that for a large gas handling plants, the pressure drop reduction at main process gas path will not only improve the throughput of the plant, but also reduce the energy consumption in the major drives. Hence, recently, importance was given towards pressure drop minimization in the front end of ammonia plant. Identification of additional pressure loss is done through accurate pressure drop survey in the front end of ammonia plant. The values thus measured are normalized to the design condition and compared with the design and historical pressure drop data.

(ii) Observations and out come of the exercise:

The exercise thus carried out revealed high pressure drop across a control valve in the inlet of the Methanation section, across the catalyst bed of secondary reformer and across the feed effluent exchanger inlet of the Methanation section.

03- HV-002 (A Control Valve at the Upstream of Methanation Section):

The purpose of this valve is to isolate the Methanation section. Globe valve was originally installed and by its nature it offered high-pressure drop (0.7 Kg / Cm^2). Normally globe valves are chosen where flow control is required. The type of valve was wrongly chosen during design stage and it was identified after many years during such survey. As this valve is kept fully open during normal operation, it was decided to replace with ball valve.

R-203 (Secondary Reformer):

The purpose of the secondary reformer is to reform the residual methane at the outlet of primary reformer. Air is introduced into secondary reformer through a ring type air burner. Inside the secondary reformer combustion takes place initially and temperature goes as high as 1600° C. Over a period of time, the burner holes become oblong and cracks are formed. This leads to improper mixing of process gas and air, shifting down the combustion zones and finally affecting the catalyst. As a result, sintering / powdering, ruby, crest formation occur.
Due to this phenomenon, pressure drop increases gradually across the catalyst bed, during the exercise the pressure drop was measured to be 1.0 Ksc, which was on the higher side.

E-311 (Methanator feed effluent heat exchanger):

This is a gas-to-gas heat exchanger of type 1-2 shell and tube. Heat is transferred between the feed and effluent gases of the methanator.

The root cause for the increase in pressure drop is due to carry over of K_2 CO_3 solution from the upstream CO_2 removal section. This has resulted in fouling of the exchanger and leading to poor heat transfer also.

A simulation was carried out using the ASPEN PLUS software and the results proved that the exchanger had fouled badly. It was found that the fouling factor of the exchanger had to be increased twice either on shell or tube side to converge final shell side outlet temperature. The actual heat transfer coefficient of 286 Kcal / Hr m2 K arrived on simulation was less than the design value of 320 Kcal / Hr m2 K.

The exchanger was opened and cleaned thoroughly with hydro jet in tube side and by filling and draining with water in the shell side.

(iii) Technical and financial analysis:

An experiment was conducted and was observed that when the syn gas suction pressure is increased by 1 Kg / Cm2, the overall compression ratio comes down from 5.64 to 5.42 resulting in a power reduction of 376 Kw. This in terms of monitory benefits translate into Rs. 54 Lakhs / Year, considering the energy cost as Rs. 320 / Gcal based on the administered NG cost.

(iv) Impact of implementation:

a) Control Valve replacement:

The existing control valve was replaced with a ball type in the plant turn around. The actual pressure drop after replacement was done and found to be 0.05 Ksc. This resulted in a pressure drop reduction of 0.65 Ksc.

Energy Savings: 11,154 Gcal / yr
Rs. 38 Lakhs / yr

b) Scooping of catalyst bed top layer in Secondary reformer:

This was carried out in the plant turnaround and the pressure drop got reduced to 0.5 Ksc from 1.0 Ksc, which resulted in pressure drop reduction of 0.5 Ksc.

Energy Savings: 8,580 Gcal/ yr
Rs. 29 Lakhs / Yr

Fig-2: The secondary reformer where catalyst scooping was carried out.

c) Cleaning of the Exchanger E-311:

This was planned and executed in the plant turnaround. Thorough cleaning of the exchanger on both shell and tube side was carried out. This resulted in a pressure drop reduction of 0.9 Ksc.

Energy Savings: 15,444 Gcal / yr

Rs. 53 Lakhs / yr

Fig-3: The Methanator feed effluent Interchanger where thorough cleaning resulted in Pressure drop reduction.