

## Energy saving and pollution control in urea plant through prilling tower and other equipment

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Most air pollution regulations can be met by existing technology available. However, technology has not yet been developed to cope with the particulate emission problems at urea prilling towers. Considerable technical effort is being devoted to finding solutions to the prilling tower problems.

One possible solution for new plants is to granulate urea in equipment which is amenable to particulate emission abatement. There are some unsolved water pollution problems at fertilizer plants awaiting further development of abatement technology.

The following paper is case study of pollution control through prilling tower and other equipment in urea plant.

# Energy Saving and Pollution Control in Urea Plant Through Prilling Tower and Other Equipments

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## **Abstract**

The paper intended a case study of pollution control through prilling tower and other equipment, in urea plant the prilling tower is main pollution contributors. In India urea production through prilling route is 100 % no granulation is used. A mathematical hydrodynamics, heat, and mass transfer between the urea and the cooling air are developed in natural prilling tower. The height of the prilling tower is about 80 meter to 110 meter according to plant load and weather condition. The formation of biuret & triuret is the loss of ammonia is the source of pollution in this process. The prilling tower is the source of pollution in form of dust and ammonia and that can be control by simple technique also energy saving in terms of ammonia saving, ammonia is the harmful pollutant if you vent and useful product if you recovers. The company developed many techniques to reduced pollution after establishment of these modifications and techniques, prilling tower emission are safer than the local environment requirements and company were received many environmental awards.

**Key words-Pollution, ammonia, dust, Prilling Tower, energy, NOx, crystallization,**

## **INTRODUCTION**

The National Fertilizers Ltd. Vijaipur is located in Madhya Pradesh (India). The Plant have two ammonia plant M/S. Haldor Topsoe Technology, Denmark capacity 1750 & 1864 TPD for line-I & line-II respectively and four urea plant of M/S. Saipem ammonia stripping process, Italy. The line-I plant installed in 1988 and that of line –II in 1997. The capacity of Urea-I urea –II is 3030 & 3231 TPD respectively. The raw material used includes natural gas, Naphtha, water and power. Three Numbers Captive power plant of capacity 17 X 3 MW are used in this complex. The national Fertilizers contribute 16 % to India's total urea

production. The technology used to produced ammonia and urea has been revamped over the years and won the managements numerous productivity excellence awards and accolades. In fertilizers Industries the prilling tower is the main pollution contributors that can be control by simple technique and it can converts to energy saving.

## **Process of Vijaipur Plant**

The process of Vijaipur followed for synthesis of the ammonia is hydro desulfurization primary reforming secondary reforming, CO shift converter, CO<sub>2</sub> absorption and regeneration in GV (Giamarco-Vetrocoke Section), Methanation-ammonia synthesis. The line-1 plant also having carbon Dioxide recovery plant for recovers CO<sub>2</sub> from flue gases to control greenhouse gases and these greenhouse gases converts to useful product urea. The plant is eco friendly having zero pollution discharge. The urea synthesis process follows High pressure CO<sub>2</sub> compressor and liquid ammonia pumping high pressure and stripping medium and low pressure ammonium carbamate decomposition. Ammonium recovery and recycles two stage vacuum concentration with one additional stage of Preconcentrator. The effluent generated in urea plant is treated in waste water treatment section with urea hydrolyzer and treated process condensate is sent to the demineralized water plant for recycling after polish water unit.

## **Prilling Tower**

Prilling is defined as distribution of molten droplets into a column of rising air which removes the heat of fusion and yield a solid product. Two most important aspect of prilling are droplet formation and distribution of droplets over maximum cross-section area of prilling tower. The jet coming out from the hole on the prilling bucket becomes unstable and becomes ready to disrupt when its length becomes about 4.5 times as that of hole diameter and dia of the prills becomes 1.89 times as that of hole diameter.

- The tendency of jet to disrupt can be expressed in terms of viscosity, density, surface tension and jet size.
- Aside from technique of dividing the jets into droplets other variables which control the urea prills are feed temperature, pressure and composition, tower diameter, forced or natural draft, air velocity in tower, height of free fall, ambient conditions and pollution control.
- At critical disturbance frequency, the jet is disrupting to form a prills. This frequency is a function of velocity of jet and distance between drops.
- Frequency of distribution can be kept constant by applying forced vibrations, which cooled lead to more uniform prills.
- Some research work is going on abroad wherein bucket will be getting forced vertical vibrations as it rotation vibrations of undesired frequency are to be masked.
- The disturbance that leads to break up of liquid jets into small droplets must be as similar as possible to produce urea prills of maximum uniformity of size and shape.
- As increase in the static pressure will result in small increase in average prills diameter.
- Prills size and distribution are function of three parameters namely vibration frequency, orifice diameter and static fluid pressure.
- The shape of the size distribution curve of a product is not affected by the change in bucket design. Size distribution is a natural phenomenon and cannot be changed. Only mean prills diameter can be changed.

#### **Zones of free fall Height**

Three zones of states take place for the prills falling from top to bottom. In first zone droplet loses its sensible heat and cools to the temperature above crystallization temp. In the second zone, the most outer layer of drop starts to crystallize and latent heat of crystallization transfers to the cooling air. In this zone most innermost layer of prills gets solidified and prills becomes completely solid. In third layer prills further cools down to lower temperature. Smaller particles would crystallize quickly and reach zone three whereas large ones may never approach zone three during their residency in the tower. Air velocity increases along the height of the tower due to the decrease in density of air because of temperature rise. Humidity of air along the height of tower increases due to evaporation of moisture from prills. Rate of change of humidity at the top is more than that at the bottom indicates most of the moisture is removed at the top when the prills is in the liquid stage.

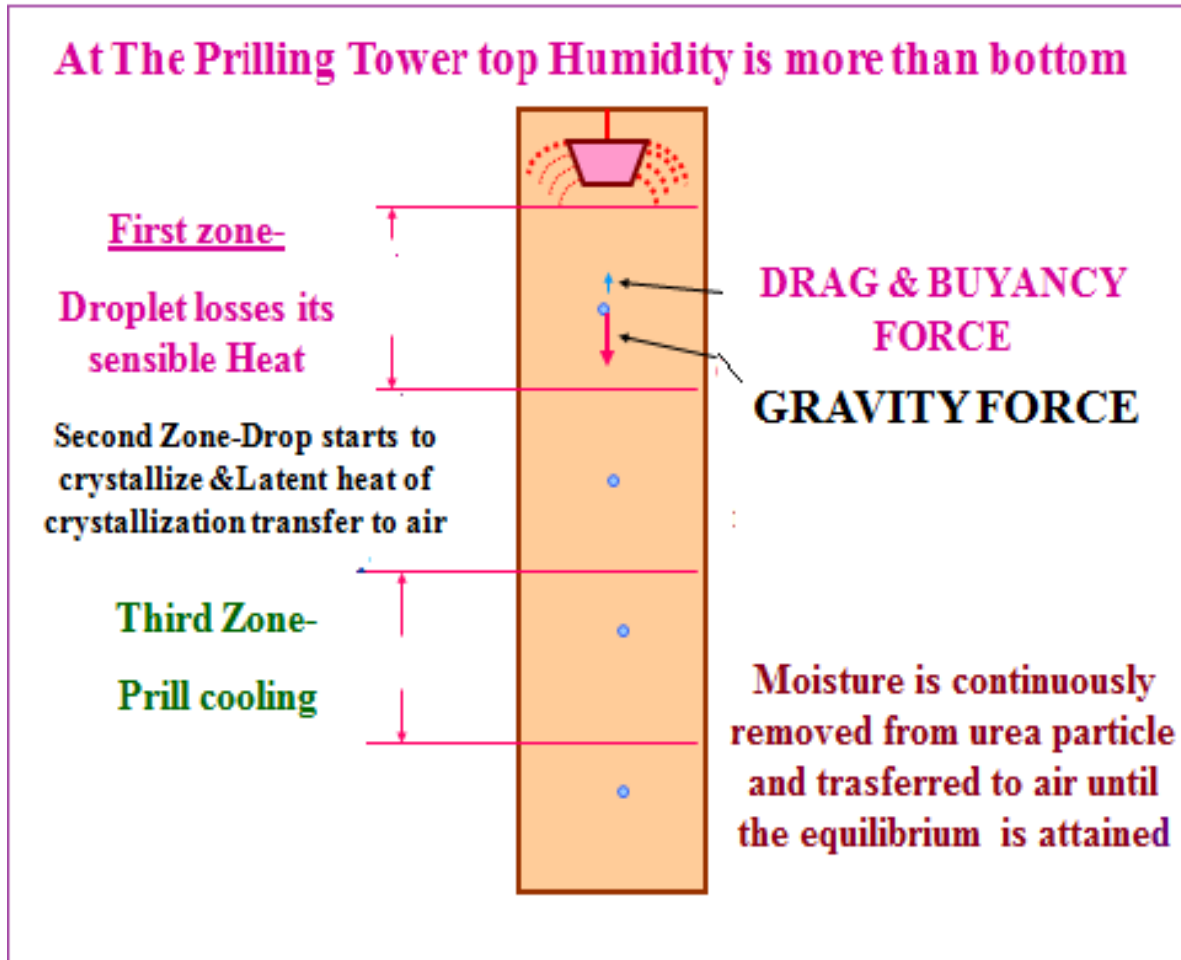


Figure No.1

Prills size varies inversely proportional to RPM of bucket and feed liquid density but varies directly proportional to feed rate, feed viscosity, feed surface tension. The Urea Melt inside the bucket takes shape of a vortex, practically parallel to the bucket wall. The Prills drum has an angle of about 5 deg to the vertical plane. This wall thickness of liquid has to be consistent all over to ensure air is not entrapped leading to hollow prills.

#### Heat Balance in Prilling Tower (Date 22/5/2016)

Heat balance of prills within prilling tower is extremely complicated phenomenon due to variable sizes of prills and different distribution patterns at different heights of tower and variable humidity pattern. However some mathematical equations are established. Following table No. 1 shows the approximation heat balance not exact.

PRILLING TOWER MATERIAL & ENERGY BALANCE						
					Date	22/05/2016
Sr. No.	Parameters	Prilling Tower urea line-II		Prilling Tower urea line-I		
1	Specific Heat of urea	0.32	K Cal /kg	0.32	K Cal /kg	
2	Urea discharge from Prilling Bucket	146000	Kg/hr	126250	Kg/hr	
3	Temperature of Urea	132.6	<sup>o</sup> C	132.6	<sup>o</sup> C	
4	Heat of Crystallization	58.4	K Cal /kg	58.4	K Cal /kg	
5	Heat of urea (Sr. No. 1 * 2 * 3)	6195072	K. cal	5357040	K. cal	
6	Heat of crystallization (Sr. No. 2 * Sr. No. 4)	8526400	K. cal	7373000	K. cal	
7	Total Heat (Sr. No. 5+ Sr. No.6)	14721472	K. cal	12730040	K. cal	
8	Prills Temperature	66	<sup>o</sup> C	75	<sup>o</sup> C	
9	Heat of Urea Prod at bottom (Sr No1 * Sr No 2 * Sr No. 8)	3083520	K. cal	3030000	K. cal	
10	Net Heat (Sr. No. 7-Sr. No.9))	11637952	K. cal	9700040	K. cal	
11	Enthalpy of Humid air(0.24 + 0.6H) Ma	(0.24 + 0.6)	Ma	(0.24 + 0.6)	Ma	
12	Where H is Humidity of air(70-75%)	(0.24 + (0.6 * 0.035)	Ma	(0.24 + (0.6 * 0.035)	Ma	
13	At 70-75 Humidity H=0.035,(0.24+(0.6*0.035)	0.261	Ma	0.261	Ma	
14	Ambient Temperature	42.0	<sup>o</sup> C	42.0	<sup>o</sup> C	
15	Prilling Tower Exhaust temperature	65.0	<sup>o</sup> C	68.0	<sup>o</sup> C	
16	Now net enthalpy of Humid air(0.261*(65-42)	0.261(65-42)	Ma	0.261(69-42)	Ma	
17	Now net enthalpy of Humid air(Sr.No.13(Sr. No. 15- Sr. No.14)	6.003	Ma	6.786	Ma	
18	For heat balance Sr No 10 & 16 equalize we get,					
19	Therefore quantity of Air ,Ma(Sr. No. 10/Sr. No.17)	1938689.32	Kg	1429419.39	Kg	
20	Moles of air(Sr. No 19/29)	66851.36	Kg Moles	49290.32	Kg moles	
21	Volumetric Flow of air(Sr. No.20 *22.4)	1497470.4	Nm <sup>3</sup> /hr	1104103.3	Nm <sup>3</sup> /hr	
22	Dust Loss from Prilling Tower	43	mg/nm <sup>3</sup>	42	mg/nm <sup>3</sup>	
23	Urea Dust losses from Prilling Tower(Sr. No. 22*Sr. No. 21)	64391226.03	mg/hr	46372336.72	mg/hr	
24	Urea Dust losses per day(Sr. 23 *24/10 <sup>9</sup> )	1.55	Ton /Day	1.11	Ton /Day	
25	Ammonia Losses	65	ppm	70	ppm	
26	Ammonia Losses(Sr. No. 25*Sr. No.21)	97335574.24	mg/hr	77287227.86	mg/hr	
27	Ammonia Losses per day(24*Sr. No.26/10 <sup>9</sup> )	2.336	T/Day	1.855	T/Day	
28	Ammonia in Prills	110	ppm	120	ppm	
29	Ammonia losses through prills(Sr No 28 *Sr No21)	164721741	mg/hr	132492390.6	mg/hr	
30	Ammonia Losses per day(24*Sr.No.29/10 <sup>9</sup> )	3.953	T/Day	3.180	T/Day	

Table No.-1

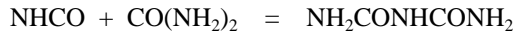
Three kinds of forces exert on the prills during their fall through tower. Gravity pulls the prills down while drag and buoyancy forces resist against gravity. Moisture is continuously removed from urea particle and transferred to air until the equilibrium is attained.

**Control of pollution and energy saving**

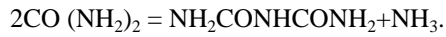
1. Control of Ammonia emission  
The ammonia can be control by following technique.
  - i. Internal Causes
  - ii. Controlling Causes\_
    - i. Internal Caused  
 $CO(NH_2)_2 = NH_4CNO + NH_3$   
 (UREA) (AMM.CYNATE) (ammonia)  
 The isocynic acid reacts with urea to form biuret.

1. Such as decomposition of urea of Prilling impact and attrition.High temperature of urea melt i.e.,>136<sup>o</sup>C and low partial pressure cause urea to decompose cynic acid.  
 $NH_2CONH_2 = NH_3 + HCNO$   
 It is observe that under normal condition the dust contain isocynic acid (HNCO)

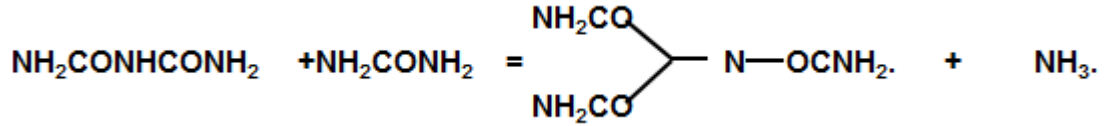
Formation of biuret takes place when urea is heated to its melting point it starts decomposition with evolution of ammonia presumably,urea first isomerizes which dissociates into isocynic acid and ammonia



In the presence of excess ammonia biuret is formed at substantially lower rate by direct reaction between urea molecules.



(UREA)                      BIURET                      AMMONIA



**Biuret Favorable Conditions-**

1. High temperature, low pressure.
2. High residence time.
3. High concentration.
4. Low Ammonia contents

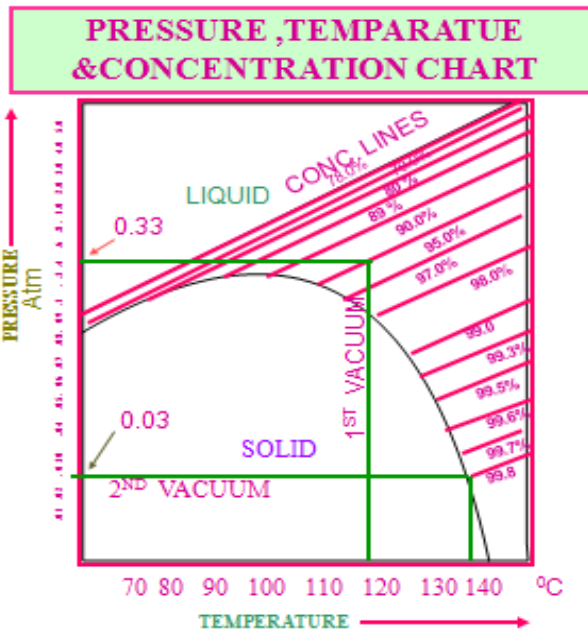
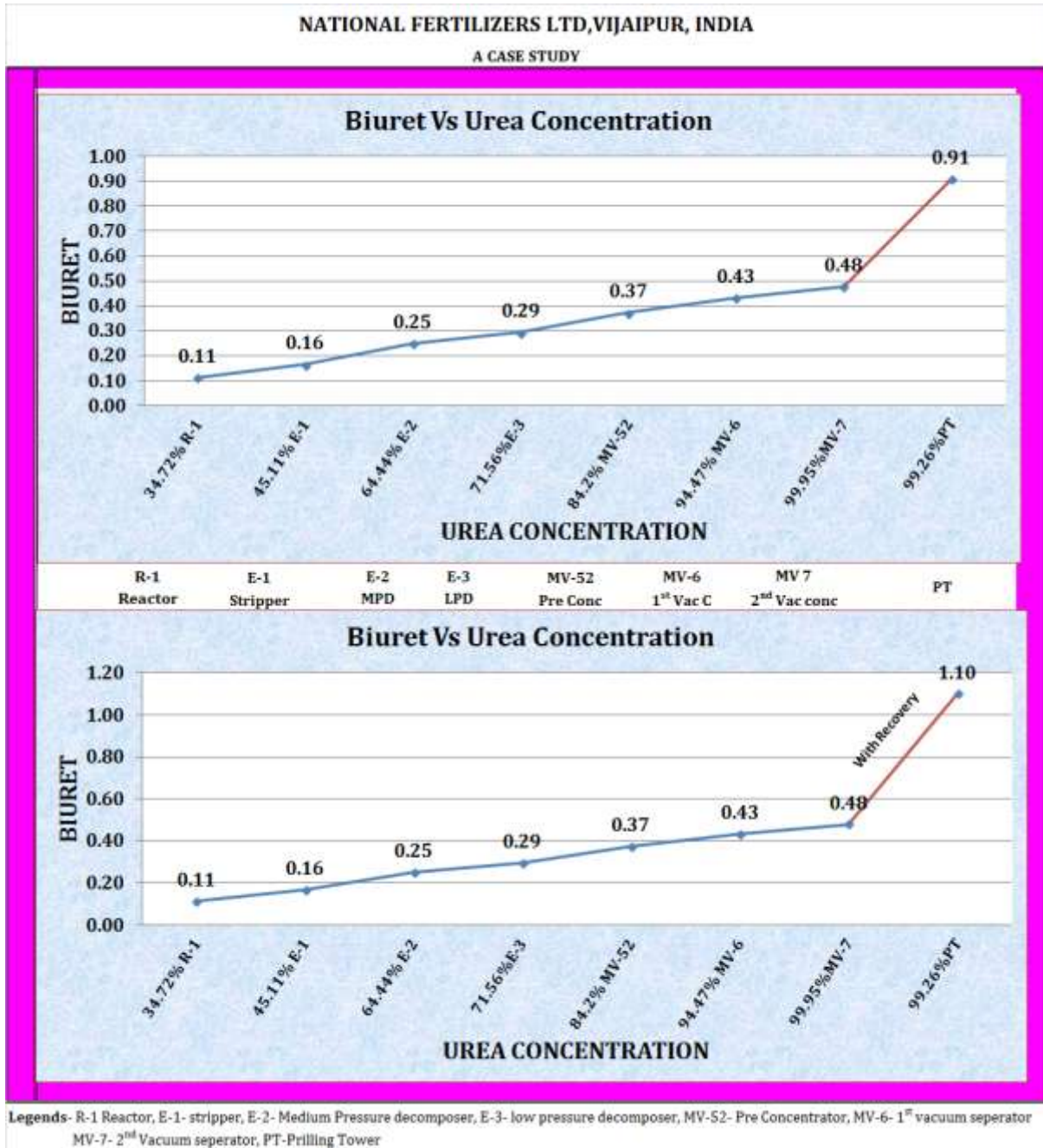


Fig No.2



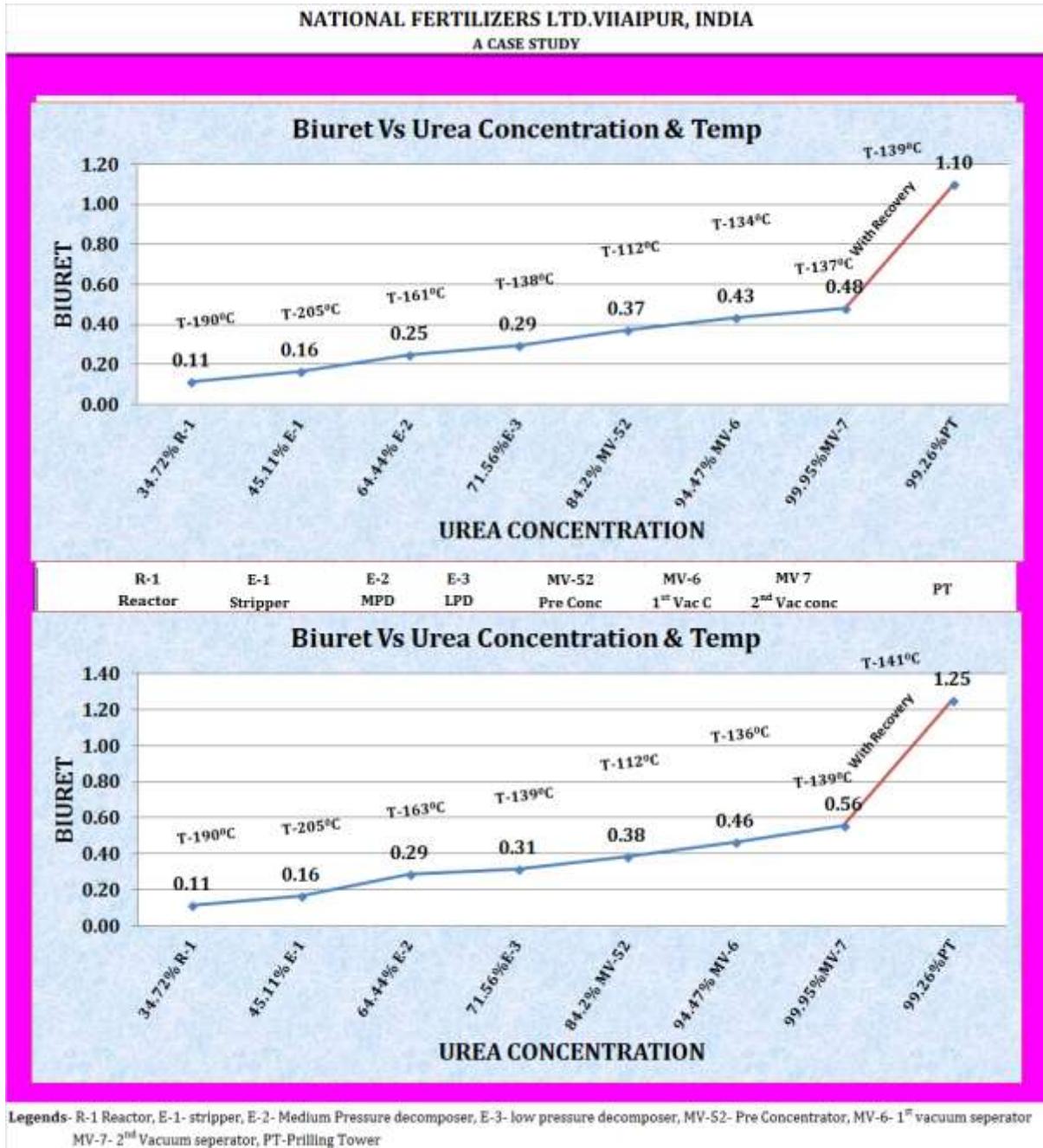
Graph No.1

Above graph shows the Biuret is maximum when Urea solution recovery is lined up, in urea tank maximum Biuret is formed, so the steam in tank should be minimum so that Biuret formation can be minimized at low temperature, also the urea tank solution should be taken immediately as soon as possible. Biuret formation means one mole of ammonia goes to atmosphere and creates pollution problem and energy loss also; if you reduce Biuret formation then you will get energy saving as well as pollution control.

**E.g. If you can control the Biuret then the free ammonia will reduce about 100 ppm in Prilling Tower exhaust.**

You can see from graph the maximum Biuret formation in urea molten pump to Prilling tower about 0.3-0.4 % Biuret formation in line, you can control the temperature of this line by control jacketing steam. Graph 1 & 2 shows the detail case studies about Biuret formation at different temperature.

E.g. At 142 °C the Biuret is about 1.1 % if you maintain the temperature 135 °C then the Biuret drastically reduced by 0.2 % to 0.3 % in this line i.e. the ammonia emission control.



Graph No.2

The above graph shows the Biuret is the function of Temperature and concentration. The controllable factor is temperature.



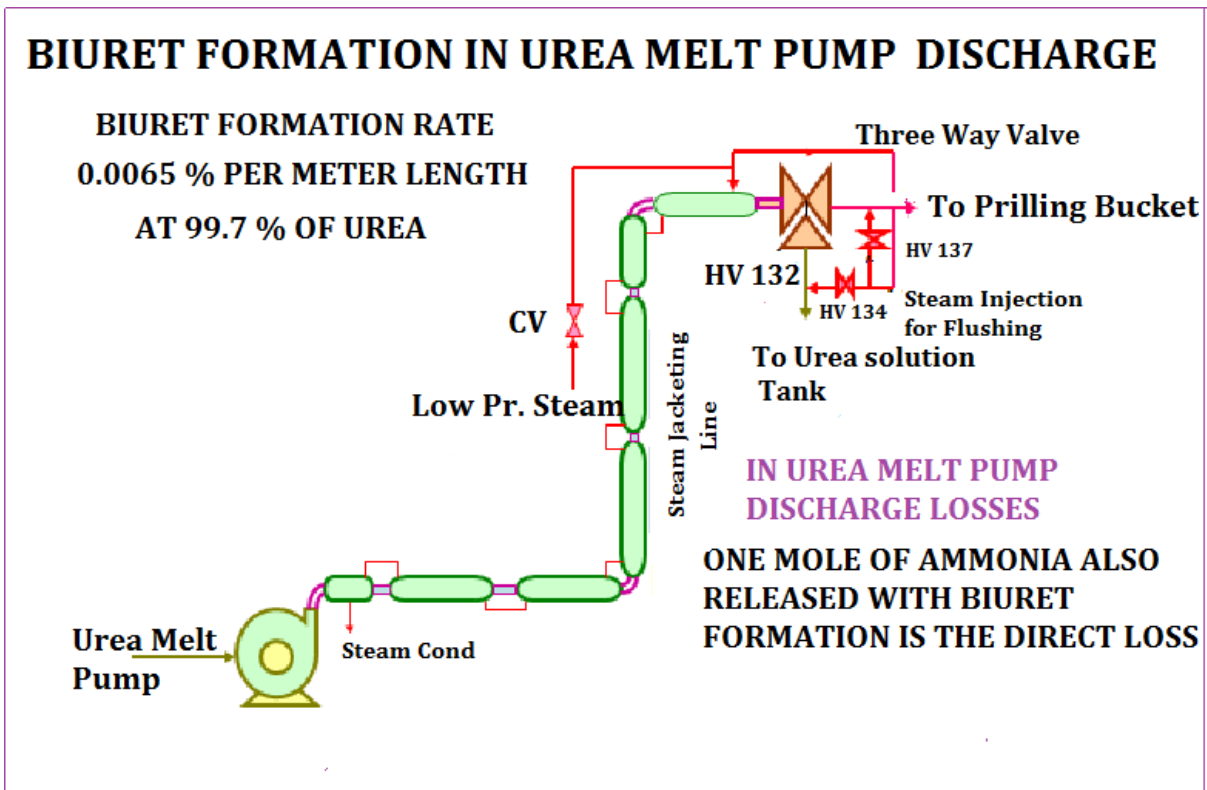
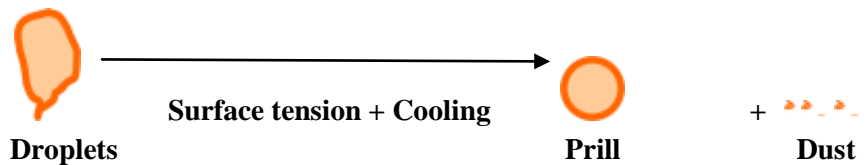


Fig. No. 3

**Dust generation mechanism**

Dust of the leaving the bucket due to cooling the small urea droplet is again formed by sublimation which cause dust formation.



Another source may be the breakage of prill due to impact after leaving the bucket if the free ammonia is present more due to process upset the dust generation is more, i.e. loss and also pollution problems.

**Effect of Moisture & Temperature on Prills( a case studies)**

Maximum strength 930 Gram/prill at 0.1777% Moisture.

Below 0.12% Moisture strength reduced 698 gram/prill.

Above 0.3% moisture strength=640 g/prill.

At 40°C Maximum strength 850 g/prill

Below 34°C the strength reduced 640 gm/prill

Above 66°C the strength reduced 640 gm/prill

The above test was carried out in National fertilizers Laboratory; this has been proved the strength is maximum at temperature 40 °C and moisture 0.1777 %

**Controlling Causes**

1. Excess temperature of bucket i.e., >136°C, at higher temperature Biuret formation takes place and also one mole of ammonia release to atmosphere.
2. Partially choked holes of the bucket.
3. Irregular holes of the bucket.

4. Overloading of plant.
5. Choking of louvers, lead to air flow restriction
6. Leakage of steam/condensate to melt line.
7. Prilling bucket overflowing due to holes choked or less rpm of the bucket.
8. Inadequate vacuum, leading to high moisture contents.
9. Excessive pressure exerted by scrapper.
10. Dissolving of dirty urea.

**Another Source of Losses.**

In Urea plant losses generally occurs from following sources.

1. Prilling Tower Dust & ammonia losses.(major losses & pollution contributor }
2. Losses from medium pressure vent
3. Losses from low pressure vent.
4. Losses from waste water section vent
5. Losses from urea handling area e.g. dissolving area.
6. Ammonia losses from blow down & vent stack
7. Other leakages in ammonia./Carbamate handling pumps etc.
8. Ammonia losses in floor washing basin.
9. Ammonia losses from atmospheric Tanks
  - (a) Urea Tank
  - (b) Waste water tank
  - (c) Tanks in vacuum sections
  - (d) Carbonate solution tank

Above losses are creates problem of pollution and also energy losses. These losses can be controlled, By following method

1. Temperature of the Prilling bucket should be maintain  $134^{\circ}\text{C}$
2. Vacuum of the both stage should be maintain as designed.
3. V-5 (urea solution tank) solution should be consumed immediately otherwise Biuret content will be high. Biuret formation means one mole of ammonia loss)
4. Louvers opening should be maintain according as ambient condition.
5. RPM of the bucket should be maintain according to size, i.e., on the wall speed & overflow speed.
6. Visual checking of product quality on continuous basis.
7. Thorough cleaning of Prilling bucket before installation.
8. Maintaining proper vacuum in both the streams.
9. Adjusting Prilling Bucket speed based on visual
10. Checking and lab reports.
11. Regular cleaning of scrapper floor and top louvers. Flushing of vacuum condensers twice a shift for maintaining proper vacuum. Flushing of vacuum separators on alternate days. Regular cleaning of Urea recovery pump strainers and ensuring no bypassing in them.
12. The vacuum and temperature may be controlled as per figure No. 2.
13. The 2<sup>nd</sup> vacuum must be controlled about 0.03 to 0.04 ata for proper concentration to avoid free ammonia in prills and also PT exhaust. Temperature may control as per figure No. 2.

AMMONIA LOSSES IN UREA PLANT				
Sr. No.	Description(with formula)	DATE	22-May-16	
		Values	Units	Ammonia
	Urea production	3500	TPD	
1	Air flow to Prilling Tower (As per design)	1460000	Nm <sup>3</sup> /Hr.	
	Urea in PT Exhaust urea dust	43	mg/nm <sup>3</sup>	
	<b>Ammonia losses through PT exhaust dust</b> (146000 * 146000/10 <sup>6</sup> *0.567)		Kg/hr.	<b>35.6</b>
2	NH <sub>3</sub> in PT exhaust	65	ppm	
	<b>Ammonia losses through PT</b> (65 * 146000/10 <sup>6</sup> )		Kg/hr.	<b>94.9</b>
3	Free NH <sub>3</sub> in Urea prill	110	ppm	
	<b>Ammonia losses through free NH<sub>3</sub> in urea prill</b>		Kg/hr.	<b>16.0</b>
4	NH <sub>3</sub> in P-33(Floor washing Pump) discharge	0.0204	%	
	Urea in P-33(floor wasing pump) discharge	0.0172	%	
	P-33 disch. flow m <sup>3</sup> / day	160	m <sup>3</sup> /day	
	<b>Ammonia losses through P-33 disch.</b> (0.0172 *1000 * 0.567 + 0.0204) * 160/24/10 <sup>3</sup> )		Kg/hr.	<b>2.0</b>
5	NH <sub>3</sub> in 31 PV - 108 (MP inerts)outlet	1.1	%	
	Flow through 31 PV - 108	875	Nm <sup>3</sup> /hr.	
	<b>Ammonia losses through 11PV 108 disch.</b> (875&1.1/1000*17/22.414)		Kg/hr.	<b>7.3</b>
6	NH <sub>3</sub> in 41 PV - 108 outlet	1.3	%	
	Flow through 41PV - 108	875	Nm <sup>3</sup> /hr.	
	<b>Ammonia losses through 21 PV 108 disch.</b>		Kg/hr.	<b>8.6</b>
7	NH <sub>3</sub> in 31PV -165(waste water vent) outlet	29	%	
	Valve opening of PV-165	22	%	
	<b>Ammonia losses through 31 PV 165 disch.</b> (875*1.3/100*17/22.414)		Kg/hr.	<b>24.2</b>
8	NH <sub>3</sub> in treated waste water	4.08	ppm	
	Urea in treated waste water	0.76	ppm	
	<b>Flow of waste water</b>	87	m <sup>3</sup> /hr	
	<b>Ammonia losses through waste water sec</b> (87*4.04/1000 + 0.76 * 87* 0.567/1000)		Kg/hr.	<b>0.4</b>
9	NH <sub>3</sub> in Urea battery limit	15	ppm	
	Flow in Urea battery limit	20	m <sup>3</sup> /hr	
	<b>Ammonia loss through battery limit</b> (15*20/1000)		kg/hr	<b>0.3</b>
10	<b>31 C-2 PSV BYPASS CLOSED</b>		kg/hr	<b>0.0</b>
	<b>31/41 PV-133(LP vent) REMAINS CLOSED</b>			<b>0.0</b>
	<b>TOTAL AMMONIA LOSSES PER HR.</b>		kg/hr	<b>189.4</b>
	<b>TOTAL AMMONIA LOSSES PER DAY</b>		TPD	<b>4.5</b>

Table No.2

Above losses can be reduced by some modification in Heat exchangers & Process recently National Fertilizers Ltd. Carried out some modification as following.-

## **1. Modification in Heat exchanger (E-11)**

### **Description:-**

In Urea plant, C-3 off gases from medium pressure section is being vented continuously to control the loop pressure. Each stream of Urea Plant generates around 700 -800 Nm<sup>3</sup>/h of C-3 off gases, so total generation of C-3 off gases is around 2800 Nm<sup>3</sup>/h. C-3 off gas comprises Hydrogen, Methane, Ammonia, Nitrogen & Oxygen in the ratio of 25-30%, 7-10%, 2.5-12%, 50-55% & 6-10% respectively. Considering the heating value of C-3 off gases, it has been utilized these gases in HRU-I & II as supplementary fuel. MP inerts washing tower absorbs ammonia from its inlet vapour comprising of inerts such as hydrogen, methane argon nitrogen & oxygen in three numbers of valve trays fitted at the top of the E-11 which is called as C-03 cold condensate at 40 °C of about 0.5 -0.8 m<sup>3</sup>/hr. is being used as absorbent which is being introduced at the top of the valve tray tower(C-3). The some amount (30-50 sm<sup>3</sup>/hr) of natural gas feed in inlet of medium pressure condenser (E-7) to avoid explosive mixture in exit of control valve because the oxygen about 8-10 % present in gases mixture.

The heat of absorption for formation of ammonical solution is being taken out through vertically installed cooling water exchanger E-11 for better heat transfer by forming falling film; E-11 has been equipped with ferrules at top having 02 numbers tangential hole of 1.5 mm dia hole. Ammonical solution while falling down through heat exchanger (E-11) gets cooled after exchanger heat with cooling water up to about 43<sup>0</sup>C and recycles back into the upstream equipment as economy of the process. Inerts along with residual ammonia was being vented to top of the prilling tower through 31/41 PV 108 and this removal of inerts are required to maintain MP loop pressure at desired range. This inerts gases along with residual ammonia is called C-3 off gas having lower calorific value in the range of 1500 Kcal/nm<sup>3</sup>.

Since commissioning of urea-II plant, C-3 off gas comprising of about 4-5% of ammonia was vented to atmosphere through prilling tower top stack continuously with flow of about 600-800 nm<sup>3</sup>/hr.

from each stream of urea-II. In 2012 these gases had been lined to HRU in CPP for recovers its energy. However line-I ammonia in off gasses are 0.5-1.2 %, in line-II plant this figure is more than line-I so the minor modification has been done to improved efficiency of heat exchanger E-11. However since October 2012, modification has been carried out for utilization of C-3 off gas as supplementary fuel in CPP HRSG burners as this gas having significant calorific value. This modification became successful with saving 2.8 G.cal /hr. resulted in financial saving of `5.00 crore. Further during capacity enhancement project of urea-II plant, process Licenser M/S. Saipem had recommended certain modification for the vapour inlet nozzle of 31/41 E-11/C-3 and the same modification, vapour inlet nozzle has been extended up to minimum bottom level of C-3/E-11 bottom solution holder from its original location of the equipment weld neck flange position.

After implementation the modification proposed by process licenser in July 2012, C-3 off gas ammonia content reduced drastically from 4-6 to 3-5 % in urea-II plant. Off gas is being used as supplementary fuel in CPP HRSG burner with flow of about 600-900 nm<sup>3</sup>/hr. from each stream with ammonia contents of 3-6 % giving higher NO<sub>x</sub> level in the flue gases of CPP, HRSG.

In May 2016 shut down cooling water exchanger of MP Inerts washing tower (E-11) has been modified by plugging about 110 peripheral tubes at top only with press fitted Teflon plug as shown in the attached photograph in figure No.4. Further one SS plate has been welded to retain the press fitted plug at its position firmly. After implementation of this modification ammonia contents in C-3 off gas has been come down to 1-2 % .Matter has been taken up with M/S Saipem & process Licenser has been agreed for proposed modification for plugging of E-11 peripheral tubes. The water contents 0.5-0.8 m<sup>3</sup>/hr is the very less quantity within 400 tubes the film in heat exchanger was not made, also the sufficient hold up level up to ferrules tangential holes on tube sheet, now the 27 % tubes has been plugged and now no problem in heat exchanger heat transfer.

Analysis of C-3(off Gas) before modification (Date 13/04/2016.)

<b>C-3 Off gas Analysis</b>						
<b>Unit</b>	<b>NH<sub>3</sub></b>	<b>H<sub>2</sub></b>	<b>Ar+O<sub>2</sub></b>	<b>CH<sub>4</sub></b>	<b>N<sub>2</sub></b>	<b>Total</b>
<b>31</b>	<b>4.00</b>	<b>25.60</b>	<b>11.90</b>	<b>10.90</b>	<b>47.60</b>	<b>100</b>
<b>41</b>	<b>5.80</b>	<b>24.76</b>	<b>11.12</b>	<b>10.12</b>	<b>48.20</b>	<b>100</b>

Table No. 3

Analysis of C-3(off Gas) after modification (Date 08/06/2016)

<b>Unit</b>	<b>NH<sub>3</sub></b>	<b>H<sub>2</sub></b>	<b>Ar+O<sub>2</sub></b>	<b>CH<sub>4</sub></b>	<b>N<sub>2</sub></b>	<b>Total</b>
<b>31</b>	<b>1.20</b>	<b>24.93</b>	<b>13.97</b>	<b>11.84</b>	<b>48.06</b>	<b>100</b>
<b>41</b>	<b>1.89</b>	<b>28.0</b>	<b>11.50</b>	<b>10.01</b>	<b>48.6</b>	<b>100</b>

Table No -4



Figure No. 4

**Benefits from this Modification**

1. About 1.160 ton ammonia saved per day from 31/41 streams and annually saving 383 Ton, in terms of urea 666 ton per year saving in terms of Currency **Rs 13654332 (in \$ 203796)**
2. NOx control in CPP HRU exhaust.

<b>C-3(OFF GASES) CALCULATION FOR ENERGY SAVING</b>						
Analysis	Ar/O <sub>2</sub>	N <sub>2</sub>	CH <sub>4</sub>	H <sub>2</sub>	NH <sub>3</sub>	Total
<b>PV 108(C-3 Off gases)</b>	<b>13.97%</b>	<b>47.6%</b>	<b>11.2%</b>	<b>24.93%</b>	<b>1.8%</b>	<b>100%</b>
Date	11/06/2016					
<b>OFF GAS FLOW IN TWO STREAM</b>			800+800 =	<b>1600</b>	Nm <sup>3</sup> /Hr	
					<b>NG CV</b>	<b>8208.4</b>
						<b>K.Cal/sm<sup>3</sup></b>
Sr. No.	Components	% in Mixture	LHV of Components, K.cal/Nm <sup>3</sup>		LHV K.cal/Nm <sup>3</sup>	
1	H <sub>2</sub>	24.9%	2579		642.94	
2	CH <sub>4</sub>	11.2%	8555		961.58	
3	NH <sub>3</sub>	1.8%	3375		60.75	
<b>LHV of Off Gas Mixture, Kcal/Nm<sup>3</sup></b>					<b>1665.28</b>	
<b>Off Gas Flow in Two stream</b>					<b>1600</b>	<b>Nm<sup>3</sup>/Hr</b>
<b>Total calorific value(1600*1665.28)</b>					<b>2664442.72</b>	<b>K.Cal</b>
<b>Equivalent quantity of NG(2664442.72/8208.4)</b>					<b>324.60</b>	<b>Nm<sup>3</sup>/Hr</b>
<b>NG Feed in 31/41 E-7(MP Condenser)</b>					<b>75.00</b>	<b>Nm<sup>3</sup>/Hr</b>
<b>Net equivalent NG(324.6-75)</b>					<b>249.60</b>	<b>Nm<sup>3</sup>/Hr</b>
<b>NG in Sm<sup>3</sup>(249.6 * 1.0554)</b>					<b>263.43</b>	<b>Sm<sup>3</sup>/Hr</b>
<b>Cost of Energy</b>					<b>₹2,607.00</b>	<b>/ G. Cal</b>
<b>Cost of one Sm<sup>3</sup>(2607 *8208.4/10^6)</b>					<b>₹21.40</b>	<b>/Sm<sup>3</sup></b>
<b>Saving per Hour(2607*21.4)</b>					<b>₹5,637.16</b>	
<b>Per Day(4.637.16*24)</b>					<b>₹135,291.85</b>	
<b>Saving Per Year from line-II</b>					<b>₹44,646,309.38</b>	

Table No.-5

**2. Modification in Process**

(Diversion of MP aqueous ammonia solution to LP section Condenser)  
 Aqueous ammonia solution (from MP section) fully utilise in E-8(Low pressure condenser) inlet line along with P-15 A/B discharge (from waste water section) for absorption of gases coming from LP decomposer. For this 1”tapping from drain upstream of 31/41 LV-103 (P-7A/B discharge) has been taken and injected just of 1” E-8 inlet line. This modification helping in reducing the temperature of top of C-1(MP Absorber) and also helping

the controlling LP pressure, The cold water to C-4(low pressure inerts tower) now reduced to zero. The modified flow diagram as shown in the figure No. -5

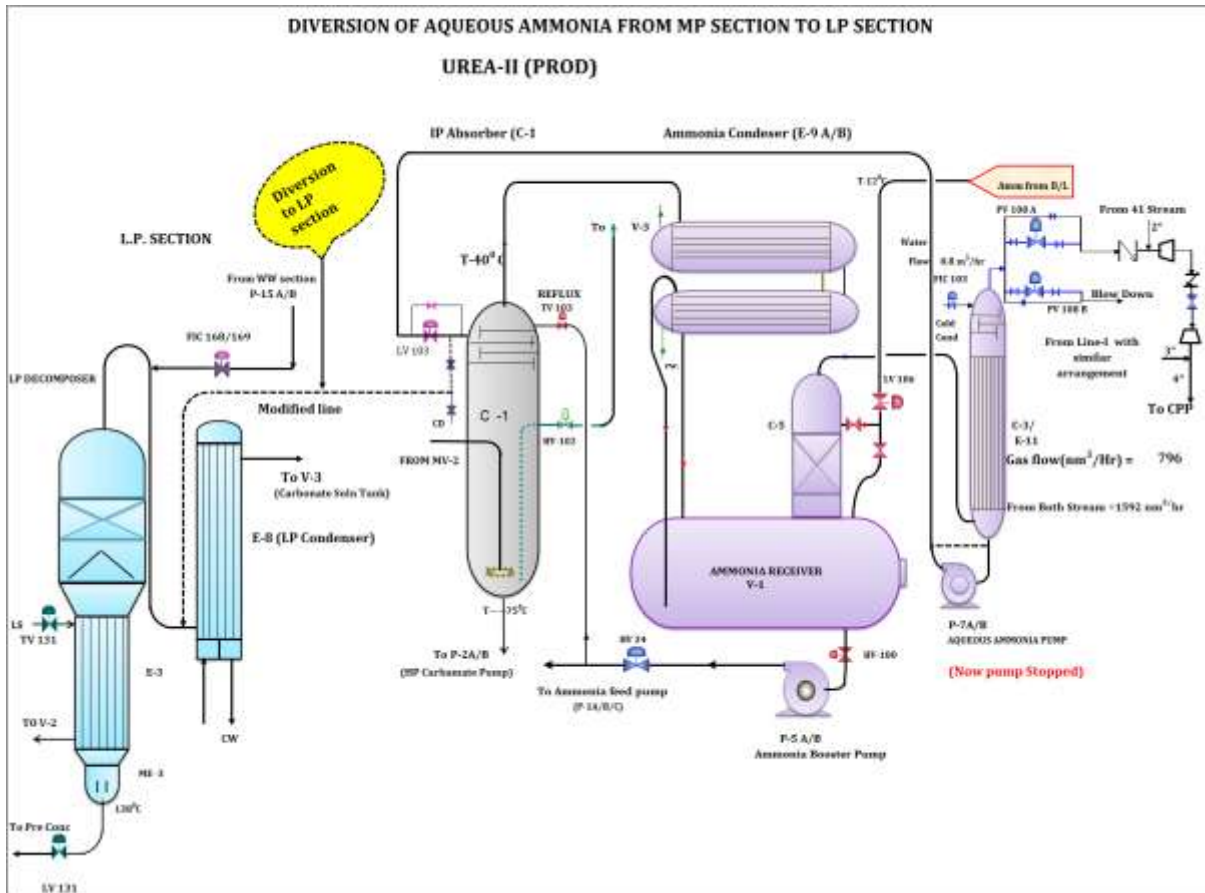


Figure No -5

In this modification the motor stopped and suction /discharge lines connected to each other. The solution transferred by differential of Low Pressure & Medium Pressure, Pump stopped i.e. saving of power.

**Following advantages with this modification**

1. Reflux to C-1(medium pressure absorber) Reduced by 2.0 m<sup>3</sup>/hr.
2. Additional water to C-4(low pressure inerts washing column) now fully stopped.
3. No limitation to increase the water flow to C-3(medium pressure inerts washing column) to minimize ammonia losses.
4. Ammonia drastically reduced in C-3 (medium pressure inerts washing column) off gas. And NOx control in HRU exhaust.
5. Low Pressure section pressure easily controlled and water reduced in C-4(low pressure inerts washing column)
6. Power saving in one stream= $VI \cos \phi \times \sqrt{3} = 440 \times 15 \times 0.9 = 10288 \text{ W} = 10.288 \text{ KWH}$  and for both streams  $2 \times 10.288$

KWH =20.567 KWH, Now Annually saving 180245.8 KWH, in Currency Rupees = **Rs 901229 (\$ 13665)**.

**Conclusion**

N.F.L.Vijaipur is very much committed to Energy management. Considering that Fertilizer manufacturing is an energy intensive process, we have realized that a small step towards within the premises of NFL shall be a great leap in the energy front of the Country and shall help in materializing the Targets. Urea prills are produced in the Prilling towers where a solidification-cooling process takes place. The ambient air is used as the cooling air stream for this process. In hot days, the temperature of the product at the bottom of the tower are hot that cannot be packed directly. In addition, in hot/humid days, prills form lumps and cakes with each other and on the scrubber. The variation of average particle temperature and moisture content is produced along the tower height as well as for the airside. The National Fertilizers Ltd, Vijaipur has always made consistent Endeavour's and efforts' towards energy conservation and continual

improvement in the direction of energy reduction and improvement in the direction of energy reduction and improvement in energy efficiency. The line-I and line-II plants have been revamped in 2012. After revamp the significant reduction of energy have been noticed. After the implementation of above modification in equipments and process the significant energy has been saved and also controls NO<sub>x</sub> in HRU exhaust in captive power plant. Now after this modification NO<sub>x</sub> was came down drastically in HRU exhaust.

**Acknowledgement**

We express sincere thanks to **Mr. R.K. Chopra**, General Manager, National Fertilizers Ltd., Vijaipur Unit, for his support and guidance in carrying out this modification & study.

**References-** The Energy saving in urea plant by modification in Heat exchanger & Process, Author- Prem Baboo. International Journal of Engineering Research & Technology, Volume. 5, Issue. 06, June – 2016.

**Legends**

- LP- Low Pressure
- MP- medium Pressure,
- LS- Low pressure steam
- MS- Medium Pressure Steam.
- SS- Stain less steel (SS 316)
- G. cal- Giga Calorie
- CPP- captive power plant
- HRSG- heat recovery steam generation
- HRU- Heat recovery unit
- INR- Indian Rupees
- PT- Prilling Tower.
- C-2 Distillation Tower.

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