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Abstract

Prilling and Granulation are finishing sections of urea production process. 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 paper intended how the 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 140 meter according to plant load and weather condition. Granules are larger, harder and more resistant to moisture as compare with prills urea. The aim of this study is to build a mathematical model for a prilling process at in National fertilizers Ltd, Vijaipur (Guna (M.P.). with productivity of 3500 tons/ day, located in India with a schematic diagram shown in Fig. 1. A numerical technique is used to solve the mathematical model in order to calculate the following parameters within the prilling tower: Key word- Energy, Granulator, heat, Mass balance, Prilling, Urea.

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, CO₂ absorption and regeneration in GV (Giamarco Vetrocoke Section), Methanation-ammonia synthesis. The line-1 plant also having carbon Dioxide recovery plant for recovers CO2 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 CO₂ 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 Pre concentrator. The effluent generated in urea plant is treated in waste water treatment section with urea hydrolyser and treated process condensate is sent to the demineralised 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.Prill 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 Prill 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 of prills within prilling tower is heights of tower. However some mathematical equations are established. As many as 300 prills per hole are produced per revolution. This easily indicates importance of individual hole on bucket.

There are three types of prilling Tower

- 1. Natural prilling Tower
- 2. Force and induced prilling Tower
- 3. Cross flow prilling Tower



Fig-1 (Prilling Tow diagram) Mathematical Model for Urea process

In the derivation of the model, the following assumptions are considered:

- 1. The droplet/ particle are spherical (from experimental measurements as shown in Fig. 2 for a shot of the particle surface under the electronic scanning microscope Steady state for the urea melt fed to the urea prilling bucket.
- 2. The pressure drop along the tower is neglected (about 0.01 Pa); therefore,

extremely complicated phenomenon due to variable sizes of prills and different distribution patterns at different

- constant pressure conditions can be applied.
- 3. Evaporation of urea in the whole process, as well as the conversion of urea to ammonia and carbon dioxide (around 0.4% as reported from the company) is neglected.
- 4. Radiation heat transfer between urea prills and the prilling tower walls is neglected (estimated about 0.6%).
- An adiabatic process is considered due to the material (concrete low thermal conductivity =0.8-1.4 W/m. K) and large thickness of the tower wall (0.25 m)
- 6. The volumetric ratio of droplets/ particles in the prilling tower is normally very small (around 0.1% only) so that the effects of droplets/ particles on each other in both heat transfer and movement are neglected.
 8) Average value of the air velocity in the axial direction is considered (0.63 m/s measured by the company).

Hydrodynamics

The prilling tower has a cylindrical shape. Thus, the prilling process hydrodynamics model is derived in the cylindrical coordinates $(r, \theta z,)$ (with the unit vectors (e_r, e_{θ}, k) in the directions of ,r θ and z , respectively. The datum of this coordinate system is taken at the air intake openings level of the tower. Whereas, for the particle heat and diffusion equations, spherical coordinates ($r_p p \theta p \phi$) are used. Three forces affect on the particle during its fall through the tower. 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 and transferred from urea particle

air until the equilibrium is attained. In other word forces are; the weight





Fig-3

 $Mp\frac{d\vec{v}p}{dt} = F_{B} + F_{D}-FW, \qquad (1)$ $\vec{F}_{W} = m_{p} g \hat{k} = \rho (\frac{4}{3}\pi r_{p}^{3})g\hat{k}. \qquad (2)$ $\vec{F}_{B} = \rho_{a}V_{p} g \hat{k} = \rho_{a}(\frac{4}{3}\pi r_{p}^{3})g\hat{k}. \qquad (3)$ where \hat{v}_{p} is the particle velocity, v_{rel} is the velocity of the particle relative to the air and $\hat{v}0$ is the unit vector of the relative velocity. The drag coefficient C_{D} is determined by the formula of [4] for the range of the particle Reynolds number Re p between $2 < Re_{p} < 500$ $C_{D} = \frac{18.5}{Re\frac{0.5}{p}}. \qquad (5)$ Where, $Re_{p} = \frac{\rho_{avaz Dp}}{\mu_{a}}$

The average air velocity is \hat{v}_{az} in z-direction and the particle diameter is Dp. The projection of the vector equation in the direction (r, φ ,z) resulted in three differential equations that solved using 4th order Runge-Kutta method using appropriate initial condition for the particle velocity.

Energy Balance

Heat transfer between the particles and the cooling air takes place along the height of the tower. Three zones of state have been assumed for each particle as it falls from the top to the bottom of the prilling tower. In the first zone, the liquid droplet loses its sensible heat to the cooling air until it reaches the crystallization temperature. In the second zone, a solid layer δ (z) begins to appear on the surface of the droplet, and hence two phases exist in each droplet liquid and solid. Heat from the core of the particle transfers to the ambient air by conduction through the liquid and solid phases of the prills. In this stage, the solid layer moves toward the centre decreasing the liquid phase until the droplet becomes completely solid. In the last zone, the solid particle loses. Sensible heat and further cooling takes place until the particle exits from the bottom of the tower at certain temperature. The three zones are shown in Fig. A

'	are shown in Fig. 4.					
	$\vec{F}_{\rm D} = \frac{1}{2} \rho_{\rm a} C_{\rm D}$ Ap $v^2_{\rm rel} \hat{v}_{0} = \frac{1}{2} \rho_{\rm A}$					
	ZONES OF	THE PRILLING TOWE	R			
	Urea	Melt Air	foutlet Z top			
	\bigcirc	Zone(1)	Zint			
	0	Zone(2)	Zfinal			
	•	Zone(3)	Z _{botom}			
	Solid y	Prills Air	Inlet			

Fig-4 (Zones of Prilling Tower)

For a spherical particle, the temperature variation only in the radial direction pr and uniform initial temperature at the top of the tower T_{init} is considered. The governing equation for the heat transfer in liquid and solid phases during the three zones, assuming constant density ρ , specific heat C, and

thermal conductivity K for the solid and liquid phases of the urea, is given as follows.

$$Cv_{z} \frac{\partial T1}{\partial z} = K \partial^{2} T1 / \partial 2p + \dots (6)$$

For $0 < r_{p} < R_{p}$, $z_{top} < z < z_{init}$,
And $0 < r_{p} < \delta(z)$, $z_{init} < z < z_{final}$,

For $\delta(z) < r_p < R_p$, $z_{init} < z < z_{final}$, And $0 < r_p < R_p$, $z_{final} < z < z_{bottom}$.

$$\rho C v_z \frac{\partial T_s}{\partial z} = K \frac{\partial^2 T_s}{\partial r_p^2} + \frac{2K}{r_p} \frac{\partial T_s}{\partial r_p}$$
(7)

The governing equations are subjected to the symmetry condition at the core of the particle and convection boundary condition at the outer .The governing equations are subjected to the symmetry condition at the core of the particle and convection boundary condition at the outer surface of the particle. where the heat transfer coefficient is obtained from the Ranz-Marshall's equation [3] as follows

$$-K \frac{\partial T_{l,s}}{\partial r_p} \bigg|_{r_p = R_p} = h_v \big(T_{l,s} \big(R_p \big) - T_a \big(z \big) \big)$$
(8)

For $0 < Re_p < 200$, 0.71 < Pr < 380,

$$Nu = 2 + 0.6 Re_p^{1/2} Pr^{1/3}$$
(9)

Where Nu and Pr are the dimensionless Nusselt and Prantdl numbers, respectively. In the second zone, a solidification process takes place. This is the well-known two-phase Stefan Problem with the conditions at the interface δ (z)

$T_1(\delta(z), z=T_s(\delta(z), z=Tm$

Urea particle size distribution (sieve analysis) was determined by experimental measurements using analytical sieve shaker for a sample of 700 g taken from the bottom of the prilling tower. The Gaussian distribution of the sample results in an average particle diameter of 1.6 mm.

$$-K\frac{\partial T_l}{\partial r_p}\Big|_{r_p=\delta(z)} + K\frac{\partial T_s}{\partial r_p}\Big|_{r_p=\delta(z)} = \rho L v_z \frac{d\delta}{dz} \quad (11)$$

The air temperature variation along the tower is obtained from the following equation, Fig. 5.

$$\rho_a \overline{v}_{az} C_{pa} \frac{dT_a}{dz} = h_v \frac{6\varepsilon}{d_p} \left(T_{l,s} \left(R_p \right) - T_a(z) \right)$$
(12)

Considering d p is the average diameter of the particles, and ε is the fraction of the tower volume occupied by the urea prills.

Mass Balance

The moisture is extracted from the prills during their fall downward the prilling tower by the humid cooling air. The transient variation of the moisture in the radial direction of the prills is given by with uniform initial moisture content of the particle Minit , symmetry boundary condition at the particle core and convection mass transfer at the outer surface.

$$p_z \frac{\partial M}{\partial z} = D \frac{\partial^2 M}{\partial r_p^2} + \frac{2D}{r_p} \frac{\partial M}{\partial r_p}$$
(13)

$$-D\frac{\partial M}{\partial r_p}\Big|_{r_p=R_p} = h_{mass}\Big(M_{r_p=R_p} - W(z)\Big)$$
(14)

The mass transfer coefficient h_{mass} is determined also from the equation of Ranz-Marshall given as follows [5]

$$Sh = 2 + 0.6 Re_p^{1/2} Sc^{1/3}$$
(15)

For $0 < Re_p < 200$, $0 \le Sc \le 250$,



Fig- 5(Slab of the tower with height dz)

Where Sh and Sc are the dimensionless Sherwood and Schmidt numbers, respectively, and W(z) is the absolute humidity of the air at the slab level. The variation of the absolute humidity of the air is determined from the mass balance as follows.

The enthalpy method is proposed for the solution of energy evaluation during the tower.

The enthalpy method is a well-known method used for solving the moving boundary problems appear in the phase change phenomena [6]. In this method, an enthalpy function E(T), which is the total heat content of the substance, is used to represent the equation. Accordingly, Eq. 6 and Eq. 7 can be written in one equation that will be as follows

$$v_{z}\frac{\partial E}{\partial z} = K\frac{\partial^{2}T}{\partial r_{p}^{2}} + \frac{2K}{r_{p}}\frac{\partial T}{\partial r_{p}}$$
(17)

The governing equation is subjected to the same boundary conditions. The solution domain $r_p(z)$ is discredited into N, M intervals in r_p and z directions with step sizes drp and dz , respectively, Fig.6

Formation of Biuret & Triuret

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 iso cynic acid and ammonia

NHCO + **CO** $(NH_2)_2 = NH_2CONHCONH_2$ In the presence of excess ammonia biuret is formed at substantially lower rate by direct reaction between urea molecules.

$2CO (NH_2)_2 = NH_2CONHCONH_2 + NH_3$			
Urea	Biuret	Ammonia	

NH2CONHCONH2 + NH2CONH2 =		NH2CO N-O-CNH2 +NH3	
Biuret	Urea	Tri uret	Ammonia

Biuret Favorable Conditions

- 1. High temperature, low pressure.
- 2. High residence time.
- 3. High concentration.
- 4. Low Ammonia contents
- Hence enthalpy of Urea-m.Cp.dt
- =146000 X 0.32 X 132.6=6195072 K.Cal.

Heat of Crystallization=146000 X

132.6=8526400 K.cal Total Heat= 6195072+8526400=14721472 K.Cal

- Prills Temperature-66^oC
- Heat of production at bottom=

0.32 X 146000 X 66=3083520 kcal

Net Heat=14721472-3083520=11637952 K.Cal Enthalpy of Humid air=(0.24 + 0.6H)Ma Where H=Humidity of air, and Ma =mass of air

Humidity of air(70-75&)= 0.24+(0.6 x 0.035)Ma =0.261 Ma

	Sr.	Variable	Value
	No.		
	1	Prilling Tower Height	107 m
ſ	2	Tower Diameter	28 m
	3	Prilling Bucket conic	23^{0}
		angle	
Γ	4	Prilling bucket speed	288 rpm
Γ	5	Temperature of inlet	$140^{\circ}C$
		urea melt	
	6	Moistute in inlet urea	0.5%
		melt	
F	7	Amount of urea melt	58333
			k.mol/day
	8	Density of air	1.166
			kg/m3
	9	Viscosity of air	1.87×10^{-5}
			Pa .S
		the second se	
	10	Specific Heat of air	1.005
	10	Specific Heat of air	1.005 KJ/Kg.K
	10 11	Specific Heat of air Total Flow rate of	1.005 KJ/Kg.K 1497470.4
	10 11	Specific Heat of air Total Flow rate of Cooling air	1.005 KJ/Kg.K 1497470.4 Nm3/hr
	10 11	Specific Heat of air Total Flow rate of Cooling air (as calculation below)	1.005 KJ/Kg.K 1497470.4 Nm3/hr
	10 11 12	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm
	10 11 12 Sr.	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value
	10 11 12 Sr. No.	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value
	10 11 12 Sr. No. 1	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220
	10 11 12 Sr. No. 1	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220 kg/m3
	10 11 12 Sr. No. 1 2	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt Melting point of Urea	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220 kg/m3 132.6 ⁰ C
	10 11 12 Sr. No. 1 2 3	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt Melting point of Urea Thermal Conductivity	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220 kg/m3 132.6 ⁰ C 2.65x10 ⁻⁵
	10 11 12 Sr. No. 1 2 3	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt Melting point of Urea Thermal Conductivity of Urea	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220 kg/m3 132.6 ⁰ C 2.65x10 ⁻⁵ KW/m.k
	10 11 12 Sr. No. 1 2 3 4	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt Melting point of Urea Thermal Conductivity of Urea Specific Heat of Urea	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220 kg/m3 132.6 ⁰ C 2.65x10 ⁻⁵ KW/m.k 1.334
	10 11 12 Sr. No. 1 2 3 4	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt Melting point of Urea Thermal Conductivity of Urea Specific Heat of Urea	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220 kg/m3 132.6 ⁰ C 2.65x10 ⁻⁵ KW/m.k 1.334 KJ/KgK
	10 11 12 Sr. No. 1 2 3 4 5	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt Melting point of Urea Thermal Conductivity of Urea Specific Heat of Urea Melting Heat of Urea	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220 kg/m3 132.6 ⁰ C 2.65x10 ⁻⁵ KW/m.k 1.334 KJ/KgK 224
	10 11 12 Sr. No. 1 2 3 4 5	Specific Heat of air Total Flow rate of Cooling air (as calculation below) Average particle size Variable Density of Urea melt Melting point of Urea Thermal Conductivity of Urea Specific Heat of Urea Melting Heat of Urea	1.005 KJ/Kg.K 1497470.4 Nm3/hr 1.6 mm Value 1220 kg/m3 132.6 ⁰ C 2.65x10 ⁻⁵ KW/m.k 1.334 KJ/KgK 224 KJ/Kgk

Prilling Tower material and Energy Balance

^{1.} Specific Heat of Urea-0.32 K.Cal/kg

2. Urea discharge fron prilling Bucket-146000 Kg/hr

Table-1 Operating Condition.

Ambient temperature-42^oC

Prilling Tower Exhaust Temperature-66^oC

Now Enthalpy of Humid air=0.261(65-42)

=6.003Ma

Now Heat balance, we get

6.003Ma=11637952

Hence Ma=1938689.32 K.Moles

Volumetric Flow of air=1938689 X 22.4 Nm³/hr

=1497470.4 Nm^3/hr . Passes through the prilling tower and it is the function of temperature. Dust Loss from prilling Tower=43 mg/Nm³

Now total Urea dust losses from P. T.

1497470.4 X 43=64391226.03 mg/hr

Urea Dust Losses per day=

64391226.03 X 10⁹ X 24=1.55 T/day

Ammonia Losses through Prill=65 ppm(from lab)

Ammonia losses=65 X 1497470.4 mg/hr =2.336 T/day.



Fig-6(Prilling Bucket) Granulation

In the fluid bed process, granular urea is produced by spraying liquid urea solution onto seed material in the fluidized state. The liquid urea is a concentrated solution and not a pure melt; the spraying occurs in the core of a fluidized layer by means of a large number of **First fluid bed cooler and final fluid bed**

cooler

First fluid bed cooler and final fluid bed cooler are standard fluid bed coolers. Fluidization air supplied by first fluid bed cooler fluidization air fan and by final fluid bed cooler 3. Temperature of Urea melt-132.6^oC

4. Heat of Crystaliization-58.4 K.Cal/kg spray heads; the particle size enlargement is achieved by accretion.

Modes of Granulation

- 1. **Agglomeration;** i.e. adhering of several particles to one another by solution acting as a binder. Agglomeration often leads to a nonhomogeneous product, with rather poor mechanical properties.
- 2. **Layering**; i.e. growth by addition of successive layers around the seed particles. Layering gives the so-called "onion skin" structure. In the layering process, a rather thick layer of solution is applied at regular intervals which then is allowed to solidify between each "dip".
- 3. Accretion; i.e. growth by continuous evaporation and solidification of a large number of minute drops of the solution onto the initial particle (seed or nucleus).

Process Description

Granulator, which consists of lower casing and upper casing, is basically an empty vessel that contains a fluidized layer of urea particles. It consists of

- 1. The perforated plate.
- 2. The lower casing
- 3. The injection headers
- 4. The upper casing

Granulator dust scrubber and cooler scrubber

Granulator dust scrubber and cooler scrubber are used to remove the urea dust entrained by exhaust air from granulator, first fluid bed cooler and final fluid bed cooler. In addition to those, there are the various deducting points i.e. elevators top, roll crushers, vibrating screens, discharge points on the conveyor belt.

fluidization air fan respectively is used as cooling medium.

Vibrating Screen and Safety Screen

The safety screens are provided in order to remove any lumps or agglomerates present in the urea granules. Vibrating screens are provided to classify the urea granule product into three fractions: oversize, undersize and on-size.

Atomization Air Compressor

Atomization air compressor supplies atomization air to the granulator, at the required pressure. The preparation to start-up of the atomization air compressor consists in a sequence of operations where the internal and external circuits and the relevant instrumentation have to be put in service in order to obtain the condition of machine ready to start. The pressure normally maintained 0.5 kg/cm²g

Bucket Elevators Conveyors and Roll Crushers

Bucket elevators are used to move the urea granules from first fluid bed cooler to the vibrating screen feeders. Belt Conveyors are provided to move the urea product to the storage. The average diameter of the final granular product is mainly determined by:The mesh size used for the screens of the vibrating screens. roller-gap-adjustment of the roll crushers By reducing or widening the gaps of the upper and lower roll pair, the rate of seeds, which are recycled to the granulator, is determined; i.e. the gap adjustment influences the total number of nuclei per time unit, onto which the urea feed solution is sprayed in the granulation chambers 1, 2, 3 and 4 of granulator. Internal partition plates (weirs and baffles) are installed inside the granulator upper casing in order to reduce back mixing. These are fitted with an adjustable baffle which can be raised or lowered. Adjusting the open gap between perforated plate and each of Major Difference of Prills and Granular Urea

the partition plates influences the granulator selectivity and the width of the granular size distribution curve at granulator discharge.

Storage Conditions / Product Temperature

Urea granules are prone to caking when stored in bulk at high temperatures and/or at increased moisture content of the granules. Under normal operating conditions of the urea granulation plant, the moisture content of granular product is below the critical limit, above which bridge formation between the granules will occur. Besides that, the end product is treated with formaldehyde, added as urea/formaldehyde UF85 to the urea feed solution, which further reduces the sensitivity to moisture pick-up. However, improper storage and loading conditions can lead to an unacceptable increase of the product moisture content. High relative humidity in the bulk storage will cause moisture pick-up from ambient air inside the bulk hall, which will result in higher caking tendency of the product. Urea granules stored at too high temperatures will also tend to cake, because of their high plasticity and the presence of residual liquid phase. In addition, the slow cooling.

Difference of Urea Prill and Granular Urea.There has been a worldwide shift from prilling of Urea to granulation because the more desirable products made in granulator. This shift has taken place to supply growing fertilizer demand for larger, harder and denser particles. The urea granules are always better than urea prills in following ways. The mechanical properties as well as the slow-release properties of Nitrogen through urea granules. Importantly, as an economical, effective, and environmentfriendly technology.

Parameters	Prilled Urea	Granula
		r Urea
Nitrogen	46	46
Contents ,wt%		
Biuret ,wt%	1.1-1.4	0.8-0.9
Moisture, %	0.35-0.45	0.3-0.4
Free ammonia,	150-190	80-100
ppm		
Granulometry	1.65 mm	2.8-3.5
,Av %		
Crushing	0.6-1.2	1.3-3.2
Strength	kg/prill	kg/gran
		ular
Losses	By Leaching	Less
	&	Losses
	Volatization	

Table-3(Difference of Prills & Granular Urea) Free ammonia in granules is less than prills, in Urea prills free Ammonia is 160 ppm while in urea granules it is less than 100 ppm. Free ammonia is the direct loss and makes with biuret formation and high temperature of urea prills solution and concentration. The Urea solution concentration for prills required 99.7 % while in Urea granules it only 97.0%. So there is less chances for formation of biuret & triuret. In Urea (NH2CONH2), N-46.6% In Biuret (NH2CONHCONH2), N-40.7%

Due large granules size, slow-release fertilizers have received increasing attention lately because the use of them could improve nutrient-use efficiency and then reduce environmental hazards. **More Beneficial due to crushing Strength**The urea granule crushing strength is approximately is about three times higher than the prills so the losses during handling is also minimum. Generally, the crushing strength about 600 gm to 1.2 Kg per prill. The crushing strength of Granule Urea is about 1.3 to 3.2 kg per granule. The crushing strength of fertilizer particles differs greatly depending on the chemical composition. Crushing strength is the minimum pressure needed to crush individual particles. Determining the crushing strength, or hardness, will help determine handling and storage requirements of a chosen granular product. Less leaching loss hence, environment friendly and less dust losses. In also prilling process. The prilling tower is the major source of emission in urea plants. The large volume of discharge untreated cooling air contain particulate urea dust 1-2 kg/ton of urea as well as ammonia 0.7 -1.0 kg/ton of urea. In force draft prilling tower this figures are 2-5 kg/ton of urea and ammonia 0.8-1.5 kg/ton of urea. Increasing the load on a prilling tower can have negative consequence of prills quality. higher moisture contents and higher temperature cause more dust formation and increased likelihood of caking problems. Urea prills stored at too high temperatures will also tend to cake, because of their high plasticity and the presence of residual liquid phase. In addition, the slow cooling at the pile surface triggers water migration within the pile.



Fig-7(Granulation Process)

Granulation Material Balance for 3850 TPD Plants



Fig-8(Process Flow diagram of Granulation section)



Fig-9 (Process Flow diagram of Urea process)





GRANULATION TECHNOLOGY FOR UREA

The prilling process is still the most largely used process for the manufacturing of solid In fact the larger urea producing urea. countries in the world like India, Indonesia, China and former USSR are still utilizing the prilling process. This choice is mainly due to the simplicity of this process that essentially consists of a prilling tower and collecting storage or bagging without any further treatment. however, the prilled product has some major drawbacks in respect of the quality of the product having low hardness, small size and tendency to cake. Furthermore the prilling process has the drawback of emitting to the atmosphere urea dust and gaseous ammonia, from the top of the prilling tower. This problem is difficult to solve because of the large amount gas ,The small size of the urea dust and the extremely low partial pressure of the ammonia contained in the gas. The problem of the pollution of the air from the prilling tower of the urea plant is becoming more and more Different Granulation Process

important because of the more respective environment protection rules and the sensibility of the population to the problem. At the beginning the above mentioned unsatisfactory characteristics of the prilled urea slightly improved by treatments with additives) pushed several companies to make efforts to improve the said characteristics. Several Granulation processes have been studied, patented, tested in pilot plants basically to make harder and larger granules suitable for easier handling in plant or shipment even pneumatic handing) as well as for blends with other fertilizers. In the last 20 several companies focused vears. their attention on the fact that another advantage of the granulation over the prilling process was the easier control of the pollutants urea and ammonia In some cases this advantages has been even more important than the advantage of a better product quality in convincing manufacturing to install a granulation unit in plants that previously were using prilling process.

Sr. No.	Company	Types of Granulator
1	TNA	PAN Granulation
2	TVA	Falling Curtain Drum Granulation
3	Norsk hydro	PAN Granulation
4	C & I Girdler(Now Bechtel)	Spherdizer Drum Granulation
5	Niro Atomizer	Fluid bed granulation
6	Fisons	Drum Granulation
7	Hydro Agri(Former NSM)	Fluid bed granulation
8	Kaltenbach Thuring	Fluid Bed Drum Granulation
9	TEC	Spout bed Granulation
10	Saipem	Falling Curtains drum granulation
11	Uhde	Fluid bed Granulation

100.

Table-4

Design of Prilling Tower

Transformation of urea from melt to solid prills takes place in the urea prilling tower. In the prilling process, urea melt is pumped to the top of 70 to 150 meter (above ground) cylindrical concrete tower where it is fed to the prilling device that called rotating bucket. The rotating bucket is a sieve-like cylindrical or conical drum that rotates about its axis. Liquid jets emerge from the various holes on the curved surface of the drum, and break up due to centrifugal and capillary instability. The liquid urea droplets formed fall downward the prilling tower. A counter current cooling air stream enters from bottom of the tower. intake openings located around the circumference of the tower at a height approximately 5-7 meters from the ground

design of the prilling tower according to plant load.as shown in the table-5.

Sr.	Urea Prod, TPD	Prilling Tower Total	Free Fall Height,	Prilling Tower Diameter,
No.		height, meter	meter	meter
1	1200-1600	96	76	27
2	1600-2000	102	80	27
3	2100-2500	110	86	27
4	2600-3000	120	90	27
5	3100-3500	130	98	27
6	3600-4000	140	100	28
7	4100-4500	142	102	28
8	4600-5000	144	104	29

Table-5

Conclusion

The only key difference between them is the internal structure of granules which is the fundamental key to their mechanical properties. The strength measurement showed that samples of granulated urea have a higher strength as their prominent size and internal structure, while prills performed weaker strength having the small size. Taken together, these findings suggest a role for urea finishing processes in affecting mechanical and physical properties of the final product. But both having advantages of their field. The bulk density of urea is less and hence packing bag required less volume. A mathematical model based on the hydrodynamics, heat, and mass transfer between the urea and the cooling air is developed. A numerical technique with an explicit scheme is used to solve the model.

References

- Urea product Quality by Prem Baboo, International Journal of Engineering Research Technilogy, Vol-07, Issue-04, April 2018
- Energy Saving and Pollution Control in urea plant through prilling Tower and others equipments by Prem Baboo, International Journal of Trends and Technology, Vol-36 No.-7,June 2016;
- 3. Study on Heat and Mass Transfer During Urea Prilling Process by Ali

Mehrez, Ahmed Hamza H. Ali, W. K. Zahra, S. Ookawara, and M. Suzuki, International Journal of Chemical Engineering and Applications, Vol. 3, No. 5, October 2012.

- Energy saving and dust management in Urea & Bagging Plants by Prem Baboo, International journal of Engineering Research and technology ,Volume-07 Issue-02 Feb. 2018.
- Urea Finishing Process: Prilling versus Granulation by Nejat Rahmaniana,*, Sina Naderia , Enes Supukb , Rafid Abbasc , Ali Hassanpour, ScienceDirect, Procedia Engineering 102 (2015) 174 – 181.
- 6. An advance book on "Fertilizers Technology" pure knowledge writer Prem Baboo, Notion Press.