International Fertilizer Industry Association

IFA Technical Conference

Johannesburg, South Africa
30 September-4 October 1996

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Date of Receipt: 20 May 1996

NPK QUALITY PROBLEMS AND IMPROVEMENT MEASURES

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RESUME

La communication met surtout l'accent sur la performance de l'unité à la suite de la réception, les problèmes rencontrés, pour les formules NP/NPK à base d'urée en ce qui concerne la granulation, le séchage et les mesures prises. Les perturbations dans la granulation du fait de l'emploi de matière première potassique enrobée dans la fabrication des engrais NPK sont également soulignées pour l'information générale. La communication aborde aussi certains essais effectués pour déterminer la tendance à la prise en masse des produits en cours de stockage en sacs, les dispositions d'empilage recommandées pour certains produits, l'essai d'agent d'enrobage de remplacement, les matériaux de substitution considérés pour le lest sableux / matières premières.

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INTRODUCTION

The Compound Fertilizer Manufacture Unit considers variety of raw materials to be bonded together in suitable proportions to achieve the desired nutrient bearing complex fertilizers as required for different agricultural crops for better yields. There are number of operations involved in the manufacture of these fertilizers viz; Reaction, granulation, drying, screening, dedusting and scrubbing. Amongst these, granulation and drying are considered the utmost critical governing operations to attain good quality product on a sustained basis. The paper describes the quality aspects of NP/NPK fertilizers.

BRIEF DESCRIPTION OF FACILITIES

Saudi Arabian Fertilizer Company (SAFCO) and National Chemical Fertilizer Company (IBN AL-BAYTAR) Plants in Jubail, Kingdom of Saudi Arabia are operating under consolidated management to produce ammonia, urea, compound/liquid fertilizers, sulphuric acid and melamine. This is one of the affiliate companies of Saudi Basic Industries Corporation (SABIC).

The installed production capacities of SAFCO/IBN AL-BAYTAR are as below:

Product	MeT per Year
Ammonia	1,200,000
Urea	1,430,000
NPK Fertilizers	500,000
Triple super phosphate	200,000
Diammonium phosphate	100,000
Liquid Fertilizers	10,000
Sulphuric Acid	100,000
Melamine	20,000

The Compound Fertilizer (CF) unit operating in IBN AL-BAYTAR comprises of three units viz; 'E', 'F' for solid fertilizers and 'H' for liquid fertilizer production.

Technology and process in brief:

The process of DAP, NP/NPK Fertilizers and the liquid fertilizers is based on FESA technology licensed through Incro, SA of Spain. The product of GTSP however is based on Jacobs slurry process. The project was handled by Technip Saudi Arabia Ltd. (TPSA), a subsidiary of TPL, Italy. The phosphoric acid for the production is imported from Morocco/Tunisia.

The process in each of the trains is described below in brief:

NPK UNIT (E-TRAIN)

In this unit, fertilizer consisting of all the three basic nutrients viz., nitrogen, phosphorous and potassium can be made. Rotary drum type granulator is the major equipment where the product is granulated. Solid raw materials are fed to the granulator in right proportions by means of belt weighing system.

Liquid ammonia and phosphoric acid are reacted in pipe reactors and sprayed onto the solids bed in the granulator. The main ammoniation reaction takes place according to the following equations.

$NH_3 + H_3PO_4$ - $NH_4 H_2PO_4$ (MAP)+Q_1 .... 1100 KCal/Kg NH_3
$NH_3 + NH_4 H_2PO_4$ - $(NH_4)_2HPO_4$(DAP)+Q_2 .... 950 KCal/Kg NH_3
$2NH_3 + H_2SO_4$ - $(NH_4)_2$ SO_4 + Q_3 .... 1400 KCal/Kg NH_3

Under the standard operating conditions for NP/NPK, ammonium phosphate slurries with a molar ratio of 1.1 - 1.4 is formed inside the pipe reactors and ammoniation will be further completed in granulator until N/P ratio reaches 1.4 to 1.8.

The granulated wet product is then dried in a rotary co-current dryer. The product is then screened, cooled, coated with anti-caking agent and sent to product storage. The oversize and fines material from the screens are recycled to the granulator. The unit is provided with a two stage Venturi scrubbing system to recover the unreacted ammonia as well as the dust emanating from the various solid handling systems, as a part of pollution control measure and recovery.

DAP/GTSP UNIT (F-TRAIN)

Diammonium phosphate (DAP) and granulated triple superphosphate (GTSP) are produced in this unit. This unit is similar to NPK unit, comprising of granulator, dryer, screens, fluid bed cooler and Venturi scrubbing system. In addition, this unit has a rock grinding and transfer system for GTSP production and also has a preneutralizer vessel in addition to pipe reactor.

DAP is produced by reacting ammonia and phosphoric acid in the preneutralizer as well as in pipe reactors and spraying the melt onto the solids bed in the granulator. The product is then dried, screened, cooled and sent to the product storage without any coating.

For GTSP production, ground rock is digested with phosphoric acid at higher temperature and the resultant slurry is pumped onto the solids bed in granulator. The product is dried and sent to final product storage without any coating.

LIQUID FERTILIZER UNIT (H-TRAIN)

This unit has facilities to produce the liquid fertilizer grade 10:34:0, 9:30:0 and then various formulations by dissolving other nutrients viz., urea/potash in the base product 10:34:0.

Ammonia, phosphoric acid are heated separately in heaters using steam as heating media and fed to a pipe reactor where the ammonium phosphate reaction takes place at high temperature forming a good proportion of polyphosphates. The product is then cooled in a cooling column and sent to raw product storage tank. This product is then filtered and sent to final product storage tank. In case of other formulations, this product will have to be taken in a dissolving tank and urea/potash/water are added as required based on the formulation. The resultant solution is then filtered and sent to final product storage tank.

The process schematic diagram for each of the above units is attached.

PRODUCTION PERFORMANCE

The actual production performance of Compound Fertilizer units subsequent to commissioning is shown in the attached table. It can be seen that number of grades were produced based on the specific market requirements during the years. The GTSP was produced during 1991 & 1993 but later it was stopped due to poor offtake of the product. 'E' unit which is designed to produce various NPK grades has also been utilized as required to produce DAP product based on market demand. The major part of production should cater to export market which however depends on the international price as the units are based on imported phos acid. Hence the units are run to meet the local market requirements and catering to firm export orders.

QUALITY OF CF PRODUCTS

The quality of high P_2O_5 grades such as 18:46:0 (DAP), 11:52:0 (MAP), 12:35:8, 11:29:19 and 14:38:0 was quite satisfactory with respect to smoother granulation operation. However urea based grades such as 16:20:0, 23:23:0, 20:20:0, 28:28:0 and 18:18:5 have resulted in granulation problems with resultant upsets in product quality. Currently NP 28:28:0 is being produced based on market demand. Efforts are taken to sustain good quality.

QUALITY IMPROVEMENT MEASURES AND CURRENT STATUS

The quality improvement measures taken up in the past and their current status is explained below.

Urea based grades:

The problems experienced in Urea based NPK grades are summarized below:

1. Fluctuation in product nutrient analysis.
2. Free Urea presence in product.
3. Low crush strength of the product.
4. High moisture content in product.
5. Product caking.
6. Material build up in the equipments.

The actions taken for improving product quality are as follows:

1. Reducing Urea particle size

The particle size of the granular urea was 2-4 mm which was identified to be the major source of the problem as it was too big for producing a matching granular size NPK product. The miscibility of urea in the granulator was not effective and the product was not homogeneous in quality. Considering this, efforts were taken to use relatively smaller urea granules by changing the screen size in urea plant which affected urea production to some extent. The urea size after this was 2-3 mm. The granulation though improved, yet the problem of free urea presence in the final product existed. Hence it was decided to use prilled urea from the neighbouring company which is less than 2 mm size.

2. Using Prilled Urea

The trial of using prilled urea was carried out in January, 1994 for a complete run of NP 23:23:0. The granulation was smooth and the quality of the product was found to be relatively better than using granular urea. The fluctuation in nutrient analysis got minimized and the free urea presence also got reduced to almost zero. The results are given in Table 2. The product did not show caking tendency based on the accelerated caking test conducted in the laboratory.

3. Improving Dryer operation

The material build up in the dryer was minimized by controlled firing in the combustion chamber to reduce the problem of urea fusing at dryer inlet. Dryer operation was improved by maintaining good air sweep in the dryer with the necessary adjustment of Dryer fan dampers. The product moisture could be maintained between 0.9 to 1.0% with good air sweep in dryer under controlled firing as stated.

4. Increasing Sulphuric acid flow to Granulator

Attempt is also done to increase the granulation bed temperature by increasing sulphuric acid and ammonia with corresponding reduction in urea nitrogen. The crush strength of the product is around 1.0 to 1.5 Kg.

The product NP 28:28:0 provided an edge over the quality as compared to other urea based grades owing to the non requirement of sand filler in this grade due to its formulation requirement.

Though considerable improvement could be achieved by the above efforts, it is also considered to try ammonium sulphate in place of urea after the due consultations with the process licenser M/s. Incro.

It has also been noted that some of the international customers specifically ask for nitrogen totally on ammoniacal basis which is possible only by using ammonium sulphate and ammonia in place of urea. The user experience on ammonium sulphate was reported satisfactory.

The use of ammonium sulphate is expected to provide the following advantages:

- Eliminates / minimizes sand which is used as filler. Due to the insoluble nature of sand, it tends to physically segregate and weaken the product. The tendency gets enhanced when more of sand is used as required depending on the formulation to be produced.

- Unlike sand, ammonium sulphate is soluble and can physically integrate within the granule.

- Eliminates / minimizes urea content.

- Ammonium sulphate has high critical relative humidity (CRH) as compared to urea. Hence it improves the resistance to moisture absorption in storage. The urea on the other hand reduces the CRH of products significantly when it combines with other raw materials as can be seen in the chart attached.

- The corrosion effects on the equipments/structures will be minimum as compared to the use of urea.

- The crush strength of the product is expected to be more. Hence more handling of the product will not lead to disintegration of the product.

- Ensures overall good product quality.

However, ammonium sulphate has to be imported for use in addition to phosphoric acid. Hence this option will be viewed with techno economic changes based on the fluctuations in the international product price situation as stated earlier.

Coating of product

The coating of the product is another important area where constant efforts are necessary. This is normally achieved by frequent cleanup of the coater internals and by maintaining the spray nozzles clean inside the coater for effective liquid spray. The coating protects the product from moisture ingression during transport and also in storage, thus helping a great deal in preventing product caking/lump formation.

Presently, we are using an aminated powder which actually protects the product against moisture absorption and it is fixed to the NPK product by spraying non aminated paraffinic coating oil at 80°C. The use of powder causes dust generation in the bagging area at times. Efforts are being made to keep the oil flow more than design to fix the solid powder on to the product though it may cost additionally a maximum of about one US Dollar per MT of product.

The use of powder has been causing operational dosing rate changes whenever complaints on dusting were received from bagging section. To avoid this problem, alternatives were looked into for using a single liquid aminated product than using the combination of solid and liquid as at present. A trial was also conducted using the single liquid coating agent supplied by a foreign supplier.

The trial gave satisfactory results. Trials on alternative coating agents are under consideration to choose the best fit material for NPK products.

Potash based NPK grades

The potash based grades viz; 14:38:10, 12:35:8, 12:27:18 and 11:29:19 were produced based on white sulphate of potash as raw material. The high potash grade 12:27:18 was tried for the first time during mid 1993. The available pink potash earlier bought was used at that time in the process which was not miscible with other raw materials due to the application of a coating in this material by the vendor during its manufacture which resulted in product nutrient analysis upsets. The product also developed caking tendency susbsequently. Hence the vendor specification for potash was reviewed in detail in the subsequent orders to avoid any organic material present in it for eliminating the reccurence of the problem.

Possible alternative to sand

The problem of sand was already addressed earlier in the report. The possible substitute material for filler can be clay or gypsum. The use of ammonium sulphate in some NPK products however will reduce the use of filler to a great extent. The gypsum, a byproduct of phosphoric acid plant can however be dried well and tried in the plant in place of sand as filler. The clay can be better binding material than sand but still the effects of its use in the product to be seen. Both the materials however require a trial in the plant. These alternatives are under consideration.

Product caking

Several lab tests are done to assess the quality of NP/NPK products such as accelerated caking test, trends on moisture content in product and crushing strength.

In addition to these, a storage test was also conducted to determine the product caking tendency with respect to time and the effect on stacking the product bags in storage.

72 MeT of NP 23:23:0 (50 Kg bags) was stacked in a separate location in the warehouse for six months in 12 piles i.e. 3 stacks per pile with 2 MeT per stack. The analyses as stated above were carried out for the product in bags from each pallet. The results indicated that the bags in bottom pallets below the 2 stacks showed appreciable caking tendency and the product in the top two stacks was almost friable. Considering this, it was recommended to have two stack arrangement particularly for NP/NPK products using urea as nitrogen substitute.

Micronutrients

The addition of micronutrients such as zinc and sulphur in DAP was requested by some customers. Molten sulphur and ZnO are required as raw materials which are to be added in molten form to granulator. This requires additional system and is under study.

CONCLUSION

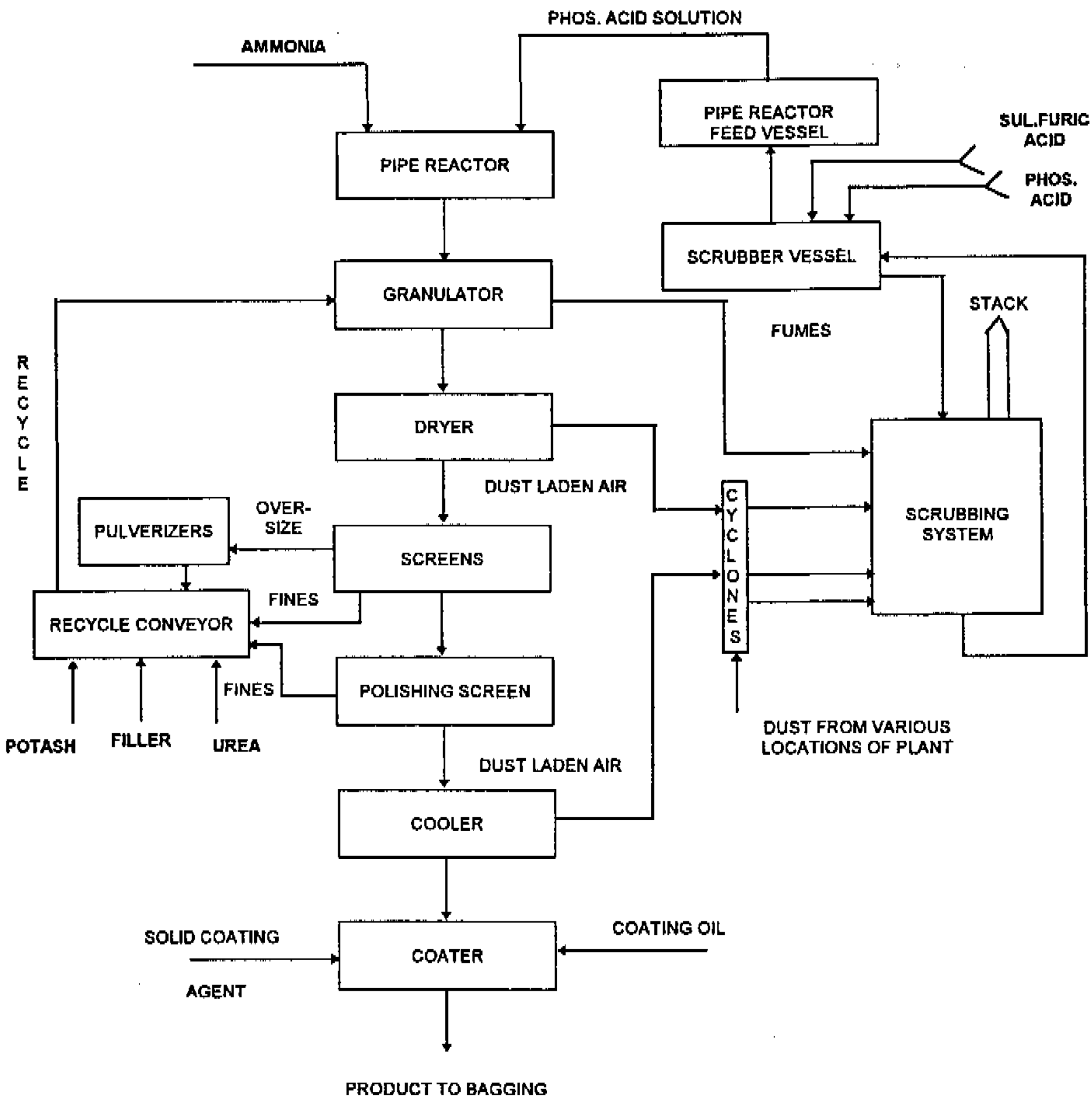
The number of product quality improvement measures were taken up in the past with the available raw materials as stated above. Number of other possible substitute materials are on the look out for further improving quality which will go with the marketing prospects in the international arena.

Acknowledgement

We sincerely thank the organizing committee of International Fertilizer Association (IFA) for selecting this paper for the presentation. Our profound thanks go to our management for nominating us to present this paper.

IBN AL-BAYTAR

NPK PROCESS SCHEMATIC DIAGRAM



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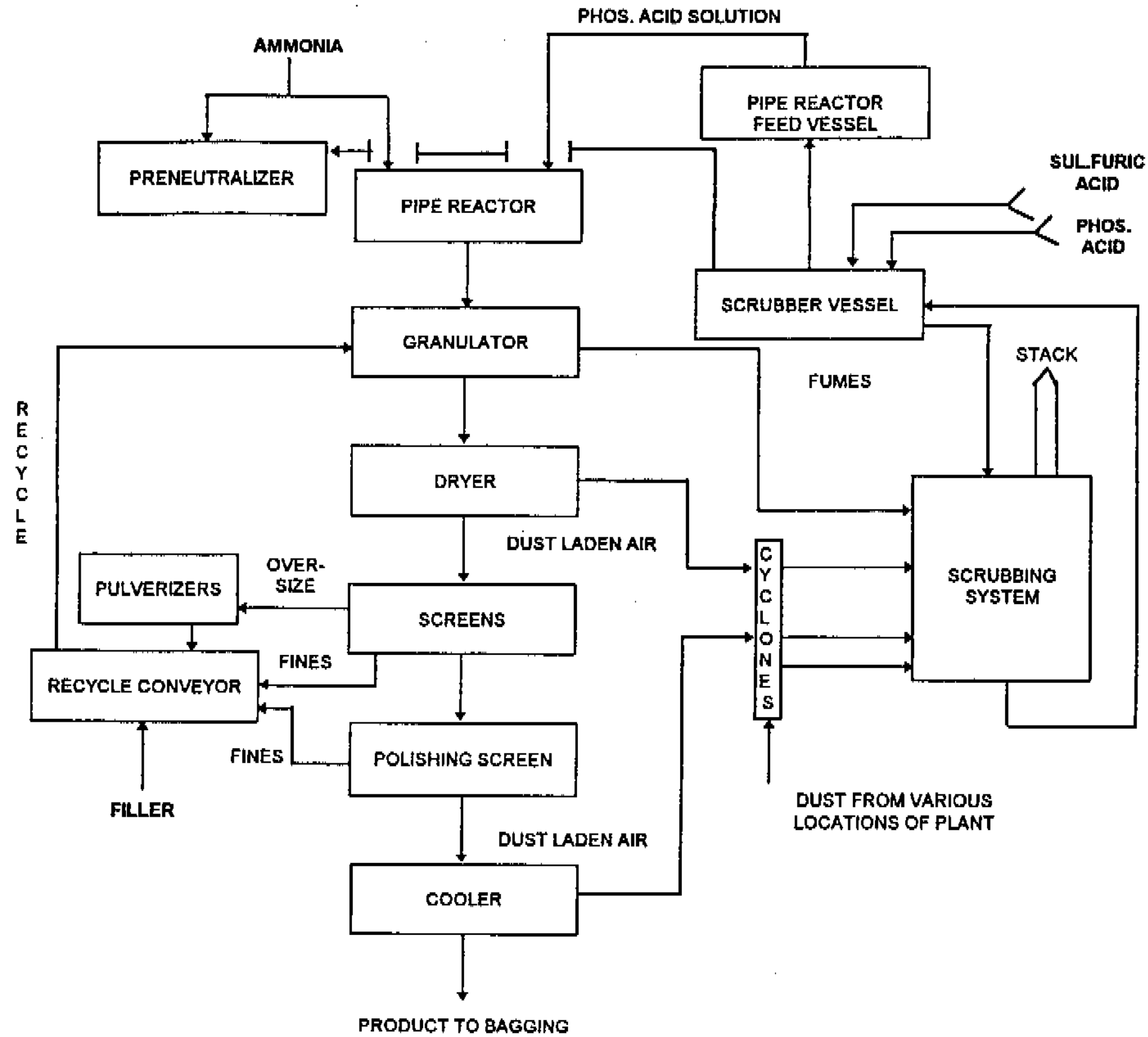
DAP PROCESS SCHEMATIC DIAGRAM



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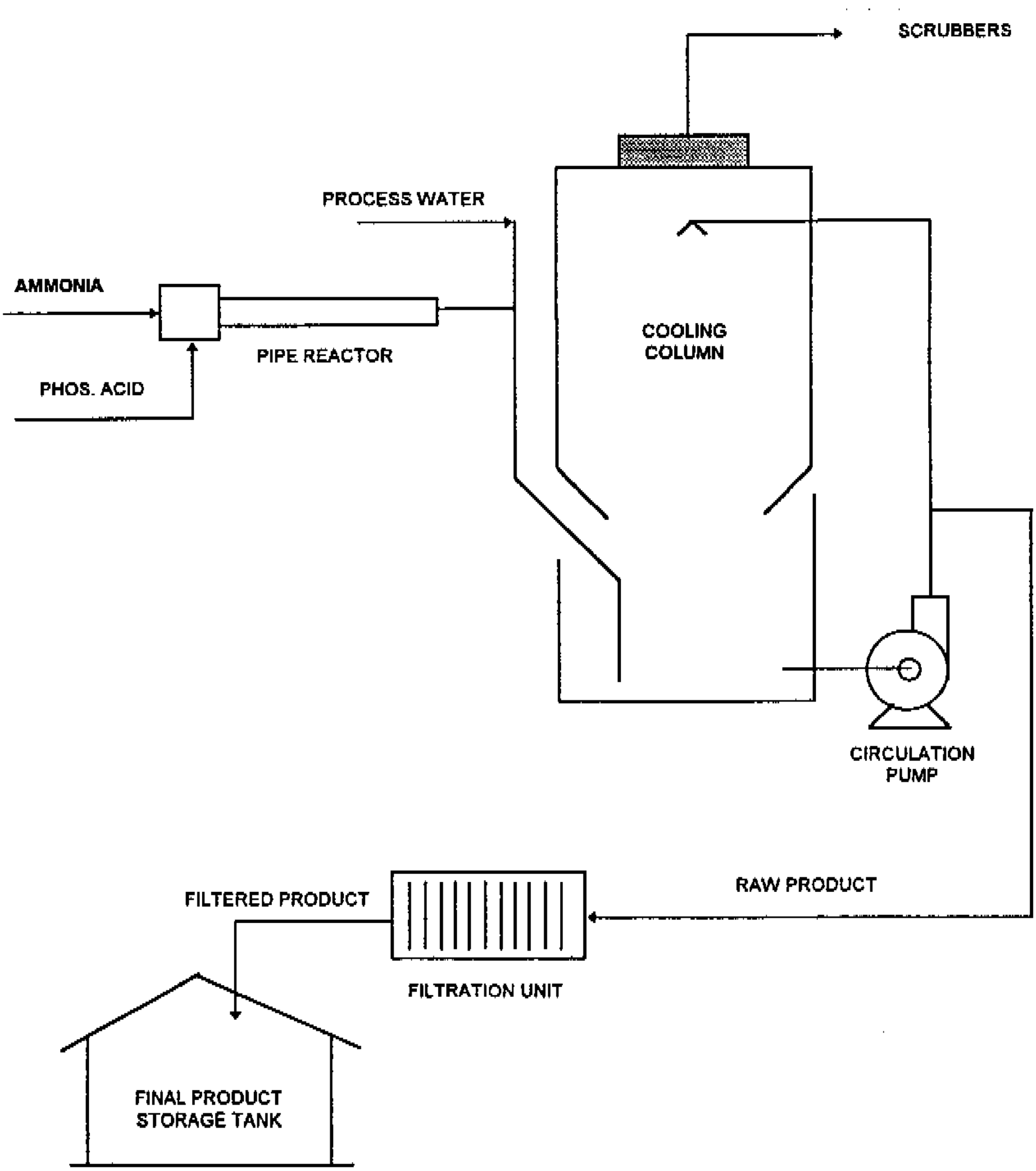
LIQUID FERTILIZER PLANT SCHEMATIC DIAGRAM



ابن البيطار

COMPOUND FERTILIZER PLANT

PRODUCTION DETAILS GRADEWISE SINCE COMMISSIONING

YEAR	1990			1991			1992			1993			1994			1995		
UNIT	'E' TRAIN	'F' TRAIN	TOTAL	'E' TRAIN	'F' TRAIN	TOTAL	'E' TRAIN	'F' TRAIN	TOTAL	'E' TRAIN	'F' TRAIN	TOTAL	'E' TRAIN	'F' TRAIN	TOTAL	'E' TRAIN	'F' TRAIN	TOTAL
DAP	7,099	108,739	115,838	153,442	360,969	514,411	76,245	305,541	381,786	88,143	197,667	285,810	137,869	181,885	319,754	64,641	191,288	255,929
MAP				12,855	-	12,855	17,216	-	17,216	10,088	-	10,088	-	-	-	16,081	-	16,081
GTSP					10,140	10,140	-	-	-	-	20,718	20,718	-	-	-	-	-	
N.P																		
16-20-0	-	-	-	18,262	-	18,262	10,611	-	10,611	-	-	-	-	-	-	-	-	-
20-20-0	-	-	-	457	-	457	-	-	-	15,478	-	15,478	-	-	-	-	-	-
23-23-0	34,407	-	34,407	109,282	-	109,282	44,893	-	44,893	16,666	-	16,666	24,003	-	24,003	14,141	-	14,141
28-28-0	-	-	-	13,230	-	13,230	-	-	-	18,013	-	18,013	13,207	-	13,207	13,914	-	13,914
N.P.K																		
12-35-8	31,441	-	31,441	42,943	-	42,943	6,468	-	6,468	13,513	-	13,513	-	-	-	-	-	-
18-18-5	-	-	-	10,980	-	10,980	10,989	-	10,989	7,527	-	7,527	-	-	-	-	-	-
14-38-10	-	-	-	-	-	-	13,382	-	13,382	26,705	-	26,705	13,868	-	13,868	6,283	-	6,283
12-27-18	-	-	-	-	-	-	-	-	-	5,339	-	5,339	-	-	-	-	-	-
11:29:19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15023	-	150,23
LIQUID FERTILIZER																		
10-34-0	-	-	92	-	-	941	-	-	1,444	-	-	1,126	-	-	1,198	-	-	-
9-30-0	-	-	-	-	-	-	-	-	-	-	-	105	-	-	419	-	-	1,133

Table - 2

Urea particle size vs product quality

Item	Granular Urea (3-4mm)	Granular Urea (2-3mm)	Prilled Urea (<2mm)
Average Crushing Strength (Kg)	1.8 - 2.3	1.8 - 2.3	1 - 1.5
Moisture content (%)	0.8 - 1.0	0.8 - 1.0	0.9 - 1.0
Homogenity	Poor	Fair	Excellent
Nutrient analysis	Wide fluctuation	Narrow fluctuation	Steady
Free Urea in product (%)			
- As such	3.6	3.0	<1
- After water sprinkling	20	18	<1

CRITICAL RELATIVE HUMIDITY (CRH %) FOR TWO COMPONENT BLENDS