International Fertilizer Industry Association

IFA Technical Conference

The Hague, The Netherlands
6-8 October 1992

International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

GRANULATION OF HYGROSCOPIC FERTILIZER ANP AND CAN

R.C. Desai and V.K. Karia,
Gujarat Narmada Valley Fertilizers Co. Ltd. India

ABSTRACT

Gujarat Narmada Valley Fertilizers Co. Ltd. (GNFC), one of the most successful and professionally managed Joint Sector industrial giant, began commercial production when Phase I projects were implemented. These included the latest addition of nitrophosphate fertilizer complex (NPP). In NPP, both calcium ammonium nitrate (CAN) and ammonium nitrophosphate fertilizers are produced, using drum granulation and pug mill granulation technology respectively. This paper enlists various factors affecting the granulation of these hygroscopic fertilizers.

INTRODUCTION

Gujarat Narmada Valley Fertilizers Co. Ltd., a Joint Sector undertaking, is one of the most successful industrial enterprises in India. Commercial production of Phase I plants, comprising of fuel oil based ammonia plant (1350 tpd) and urea plant (1800 tpd) began on 1st July 1982.

During the first decade of success, GNFC added more plants, like formic acid (5000 tpa), captive power plants (2 x 25 mW), a weedicide plant to produce butachlor (600 tpa), two methanol plants (20,000 tpa and 1,00,000 tpa), printed circuit board plant, a two Wheeler factory etc. The latest addition is a giant nitrophosphate fertilizer complex comprising of a dilute nitric acid plant (630 tpd based on 100 % Concentration), a concentrated nitric acid plant (100 tpd), a calcium ammonium nitrate plant (CAN 475 tpd), and an ammonium nitrophosphate plant (ANP - 475 tpd). CAN Plant is based on Uhde's Pug Mill technology and ANP is based on drum granulation technology from BASF.

NPK Production Technology

Out of various technologies available for NPK production, GNFC decided to go in for Uhde's pug mill technology for CAN, ODDA Process for production of NP acid/ammonium nitrate and drum granulation for ANP granulation.

This paper deals with factors involved in granulation of both CAN and ANP.

GRANULATION OF CAN

Granulation of CAN depends on following factors:

Quality of Lime

Our plant is designed to use chemcial lime (chalk) produced in ODDA section. Proper control of operating parameters in crystallization, filtration and conversion sections are very important to produce proper quality of chalk. Quality and source of rock phosphate also affect the quality of chalk. Following should be borne in mind for quality control of chalk.

Source of Rock Phosphate: Some rock phosphates tend to produce finer lime whereas other tend to produce coarser lime. It is observed that granulation is better with fine chalk having "long" crystal structure e.g. natural lime has larger crystal and hence granulation is better.

Presence of impurities in chalk: Presence of some impurities like organic matter can increase reactivity of lime with ammonium nitrate considerably, resulting in following reactions:

$$2\ NH_4NO_3 + CaCO_3 \longrightarrow Ca(NO_3) + (NH_4)_2\ CO_3 \quad (1)$$

$$(NH_4)_2\ CO_3 \longrightarrow 2\ NH_3 + CO_2 + H_2O \quad (2)$$

Chemical chalk can contain many more impurities, due to disturbances in upstream sections. A simple way to check this is to either measure and control P_2O_5 or conductivity both of which give an idea of the extent to which chalk is free of impurities.

Similar reactions also occur if chemical lime is very fine i.e. it has very large surface area. When these reactions occur, content of granulator feed vessel shows heavy foaming tendency due to release of gaseous ammonia and carbon dioxide.

If such phenomenom occurs inside granulator (when mixing vessel is by passed and feed is directly introduced to granulator), the released gases do not permit formation of granules, i.e. granules starts breaking and powdering. The above problem can be solved by reducing reactivity of lime by addition of ammonium sulfate to ammonium nitrate melt (or addition of sulfuric acid to AN melt). Addition of crystaline ammonium sulfate to mixing vessel or granulator is NOT helpful. By adding ammonium sulfate, following reaction takes place:

$$(NH_4)_2SO_4 + Ca(NO_3)_2 \longrightarrow 2\ NH_4NO_3 + CaSO_4$$

Calcium sulfate, precipitates as thin coating on calcium carbonate particles and thus, prevents reaction (1) and hence reaction (2).

Care must, however, be taken to restrict sulfate content in product to maximum 0.5 to 0.8 per cent as SO_4. A very high content of sulfate can make the product brittle and hence granules may start breaking.

Quality of AN Melt

pH value: It is necessary to maintain a pH value of approx. 5 for getting best granulation. A variation of pH value between 4.5 to 5.5 is acceptable. pH lower than 4.5 can cause finer granules whereas at higher pH, loss of ammonia is predominant.

Concentration: A concentration of 95 to 96 percent gives best granulation. At lower concentration, wet and coarse granules are observed. Concentration is controlled by adjusting vacuum in evaporation section.

Temperature: Normally temperature of AN melt is controlled around 150°C. However, the basic guide line is received from granulator outlet temperature, which should preferably be controlled at 108 to 109°C. This also depends upon quantity and temperature of recycle material.

OPERATING CONDITIONS OF DRY SECTION LOOP

Temperature and moisture content at granulator outlet: Figure 1 gives an idea of granulation in a pug mill granulator. Granulation factor corresponds to increase in size of granules over the pug mill.

For good granulation, the operating conditions should be maintained in the central zone e.g. at a fixed moisture content. If temperature at granulator starts decreasing, granules will become finer and vice versa.

It may be noted that at lower temperature at granulator outlet, the operating range for good granulation is wider than at higher temperature.

Air sweep through Granulator: To produce one metric ton of 25 percent CAN, we require about 750 kg of 95 - 96% AN solution, 250 kg of dry chalk (moisture approx. 0.5 percent) and 3 MT of dry (moisture approx. 0.1 to 0.5 percent) recycle mass. As such, quantity of water at inlet to granulator is approx. 13 kg per MT, of total mass. Likewise temperature is also high. This condition corresponds to some point above the line for granulation factor 2.5 indicating wet and coarse granulation. By evaporation of water in the pug mill, this water content should be reduced by 4 - 5 kg per MT which will cause temperature drop of 5 - 7°C. This is achieved by "air sweep" through granulator. Air sweep causes water evaporation and shifts the granulator condition inside GOOD GRANULATION zone. It is, therefore essential that proper draft of air is maintained through granulator. Figure 2 shows the flow of air through dry section equipment, including granulator. To ensure that "air sweep" or "draft" is adequate, following points should be checked:

- Vaccum at drying drum outlet should be checked and maintained.
- Small vacuum inside granulator should be checked by opening outlet inspection windows. There should be sufficient suction.

Recycle mass temperature: In order to bring granulator conditions to within "Good Granulation" zone, it is necessary to have proper temperature control of recycle material. This, in turn, is done by controlling temperature of hot air at inlet to drying drum.

Steam injection: Injection of stream helps to improve granulation, for a couple of hours. But if steam is continued for longer time, the granulation deteriorates. Use of steam should be done rarely and judiciously.

GRANULATION OF ANP

For ANP Plant, GNFC has used a drum granulator. ANP melt, having water content of approx. 6 to 8 percent is sprayed through a nozzle over the curtain of recycle material. At the inlet zone, there is a raw of spirals for forward movement of material followed by bucket zone. There are four raws of bucket, each having nine buckets. These buckets lift the recycle material and during upward movement, falling material form a curtain over which the ANP melt is sprayed. Plastic granules formed by coating of ANP melt over recycle mass, then moves ~~forward, cross the retention ring and then get partly dried~~ over drying zone before entering the dryer inlet chute. Pneumatic hammers are provided on top of granulator to prevent sticking of ANP melt over the inside walls.

As per experience gained by GNFC, following factors affect granulation.

Quality of ANP Slurry

Water content of ANP slurry: Water content should be controlled between 6 to 8 percent, depending upon source of rock phosphate. If it is too less, the granules become too dry and vice versa.

pH of slurry: pH should be maintained between 4.8 to 5.2. Too low pH or too high pH results in poor granulation and loss of ammonia.

Temperature of slurry: Temperature of slurry to be maintained at approx. 140°C depending upon temperature and quality of recycle material and water content of slurry.

Design of granulator:

Spray nozzle: *Angle of spray nozzle*: Different spray nozzles with different angle of spray and nozzle diameter are available. Spray angle determines the diameter of cone generated inside the bucket zone, say 20° spray angle generates smaller cone than 30° spray nozzle. Depending upon diameter of granulator drum and configuration of buckets suitable nozzle should be selected. If angle is too narrow, large quantity of slurry sprays over smaller depth of curtain resulting in coarser granulation and vice versa.

Diameter of spray nozzle: Diameter of spray nozzle decides the throughput of the plant. If compared to throughput requirement, diameter is too large, the slurry will not spray properly and large quantity will drop down close to nozzle in spiral zone - causing it to choke. Or, the length of spray could become less than required and hence larger drops of slurry may fall on recycle mass resulting in coarser granulation or choking of buckets and production of relatively large and wet granules. On the other side, smaller diameter of nozzle can result in finer and dry granules.

Orientation of spray nozzle: Orientation of spray nozzle should be so adjusted that its spray fall on the lower side of retention ring, in direction of rotation where proper thickness of curtain is available.

Configuration of buckets or lifters: As per original design, in our plant, nine buckets were provided in each row (total thirty six buckets). Heavy choking in bucket zone was, however, experienced within few hours of operation. It was felt that a heavy curtain of recycle mass is created due to large number of lifters, obstructing the flow of slurry in the initial phase itself. This caused heavy agglomeration and large quantity of slurry was dropping on lifters causing choking. Many alternatives were, then, made in configuration of lifters by removing a few of them from different raws. Finally, we now have 3 in first row, 6 in second row and 3 each in third and fourth row. This arrangement gives optimum performance.

Pneumatic hammers: Five pneumatic hammers are provided on granulator to tap the same externally to prevent deposition on slurry in inside wall. These hammers did not work and were to be replaced by mechanical type hammer.

Operating conditions/stages of granulator:

There are various stages which may occur when granulating fertilizers. The main stages are:

Too dry granulation: This is equivalent to undersize/fines granulation. Most of the granules are smaller than desired. The moisture content in the granules is too low.

Too wet granulation: That means that the major fraction of granules discharged from the granulator is coarser/bigger than desired. The moisture content in the granules is higher than desired.

Proper/good granulation: That means that the partition of undersize, onsize and oversize granulate exit granulator is in the order of 20%/60%/20% in average.

The principle of granulation is identical, both for ANP & CAN. Figure 1 discussed earlier for pug mill holds true for drum granulator also.

It is most important to understand that a granulation process in an equilibrium process. That means that there is a certain set of process parameters at which the plant runs with self stabilizing effects. If any deviation from the optimized process parameter occurs the recycle loop starts swinging/fluctuating. It normally takes a long time to stabilize the plant again. The influencing parameters are manifold e.g.

* chemical components in the melt,
* air flow through granulator,
* temperature of melt,
* temperature of hot air,
* air flow through dryer,
* screens distribution,
* screening efficiencies of coarse and fines screens,
* crushing efficiency of chain mills,
* granulation efficiency etc.

Because of these varieties of influencing parameters, it is always difficult to find out disturbing one which has caused the change of granulation conditions.

However, the following thumb rules can serve as guide lines for identification and correction of problem.

Figure 3 shows the parameters can be taken to achieve good granulation conditions after the plant has drifted into the range of dry/fines granulation.

At stage "A" assume that Bo is the present operating point defined by to, Xo, the granulation can be increased by increasing the moisture content in the granulate and reducing the granulate temperature.

Reducing moisture : content exit granulator can be achieved by e.g.:

- reducing moisture content of melt,
- reducing flow rate of melt/reducing capacity,
- increasing the recycle flowrate,
- reducing the moisture content in the recycle by increasing the burner temperature,
- increasing the flowrate of air sucked off from granulator resp. increase vacuum at inlet dryer,
- reducing the flowrate of steam supplied to granulator.

Increasing moisture content in granules exit granulator can be achieved by the opposite actions given above.

Reducing the granules temperature exit granulator can be achieved by e.g.:

- reducing the recycle temperature, resp. lower burner temp.
- increasing the recycle flowrate,
- increasing the flowrate of air sucked off from the granulator,
- reducing the flowrate of melt,
- reducing the flowrate of steam supplied to the granulator.

Increasing the granules temperature exit granulator can be achieved by the opposite actions given above.

Which measures are to be taken in order to stabilize the plant has to be thoroughly investigated because there is strong interconnection in between certain actions mentioned above. As an *example* it shall be noted that the granulator temperature will be reduced by increasing the moisture content in the melt because there is evaporation of water in the granulator.

It can be seen in Figure 3A that granulation may switch from dry to wet granulation if only moisture content is increased without reducing the granulator temperature.

The figure shows that the range of good granulation becomes wider as lower the temperature and higher the moisture content.

(B) Only by experience it can be determined how much moisture has to be increased and temperature has to be reduced to bring the plant back in the stable zone of granulation.

(C) Depending on the actual process conditions there are different possibilities to stabilize the plant. Reaching point B1 requires increase of granulate temperature to - tl. If the moisture content in the granules will be reduced by the increasing temperature because of more water evaporation.

It is also possible to increase the moisture content and the granulator temperature from Xo - X2 resp. to - t2 in order to reach stable condition.

The second alternative is better because the operating range for stable granulation is greater.

Figure 4 gives some suggestions how to stabilize the plant which operates under wet conditions.

(A) In case the recycle temperature and mass flow remains constant the plant will reach stable condition by reducing the moisture content. Thereby the temp. of granules will slighty increase because of reduced water evaporation in the granulator (Xo - X1, to - t1).

(B) Assuming the same operating point Bo as in (A) stable conditions can also be reached by reducing the granulator temperature only to - tl. Because of reduced temperature, less water is evaporated and the moisture content will sightly increase (Xo - X1).

(C) It is also possible to stabilize the plant by increasing the moisture content Xo - X1/X2 simultaneously reducing the granulator temperature t0 - t1/t2.

Alternative (C) is best in order to maximise the field of good operating conditions.

Conclusion: There are a number of factors affecting granulation in pug mill or drum granulator. By proper identification of the correct factor (s), granulation problem can be solved.

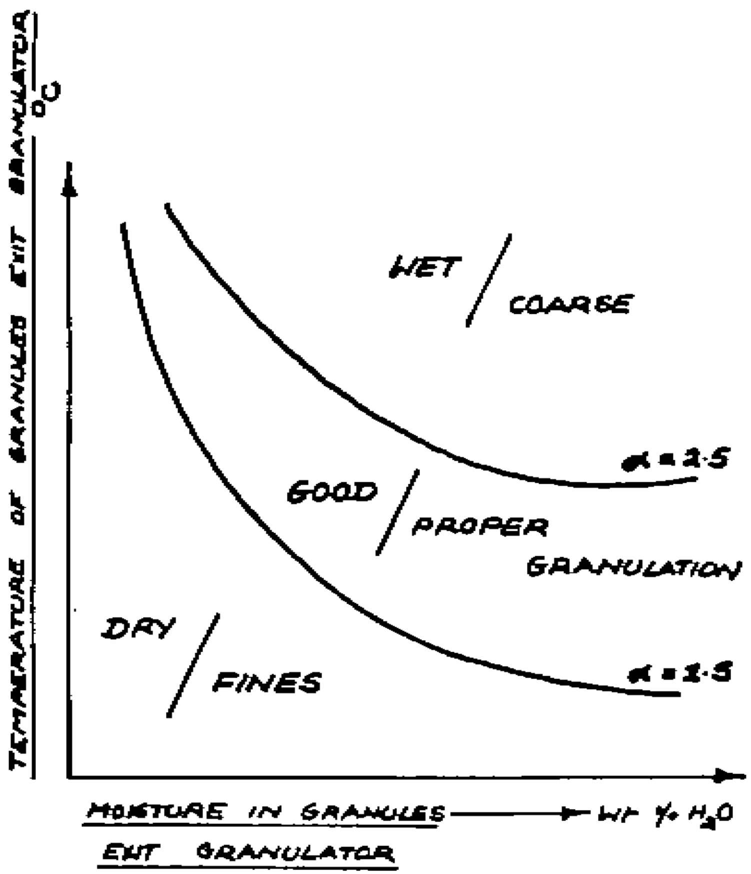

FIG.1 GRANULATION CONDITION

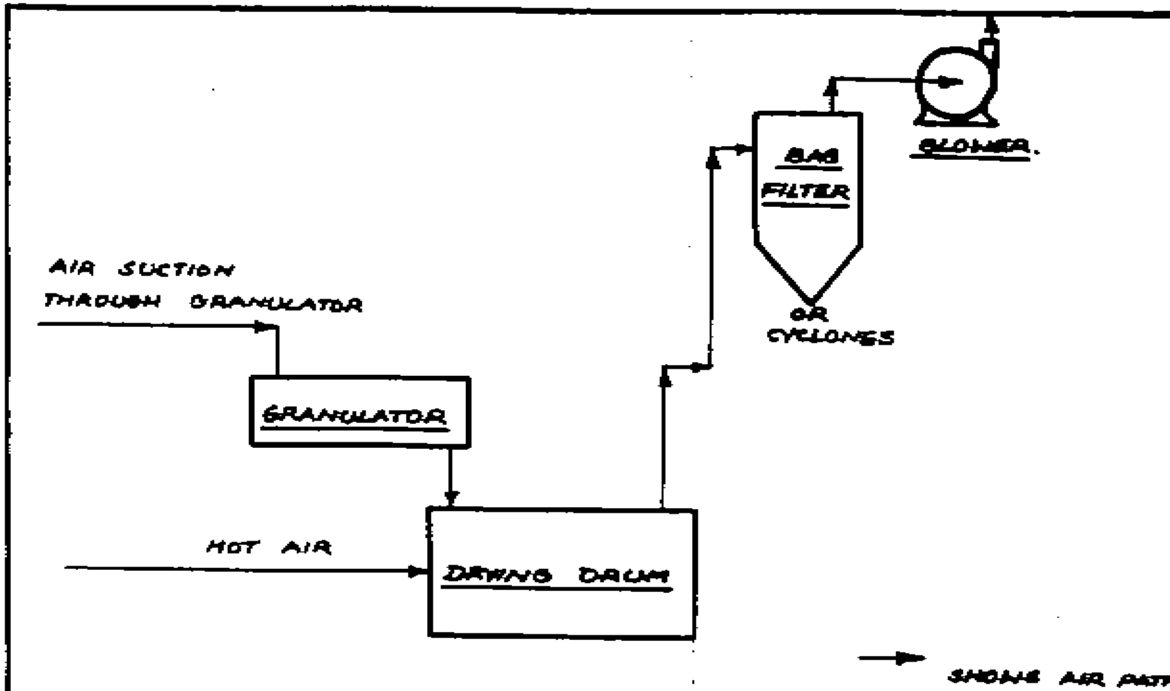

FIG 2. AIR SWEEP ROUTE

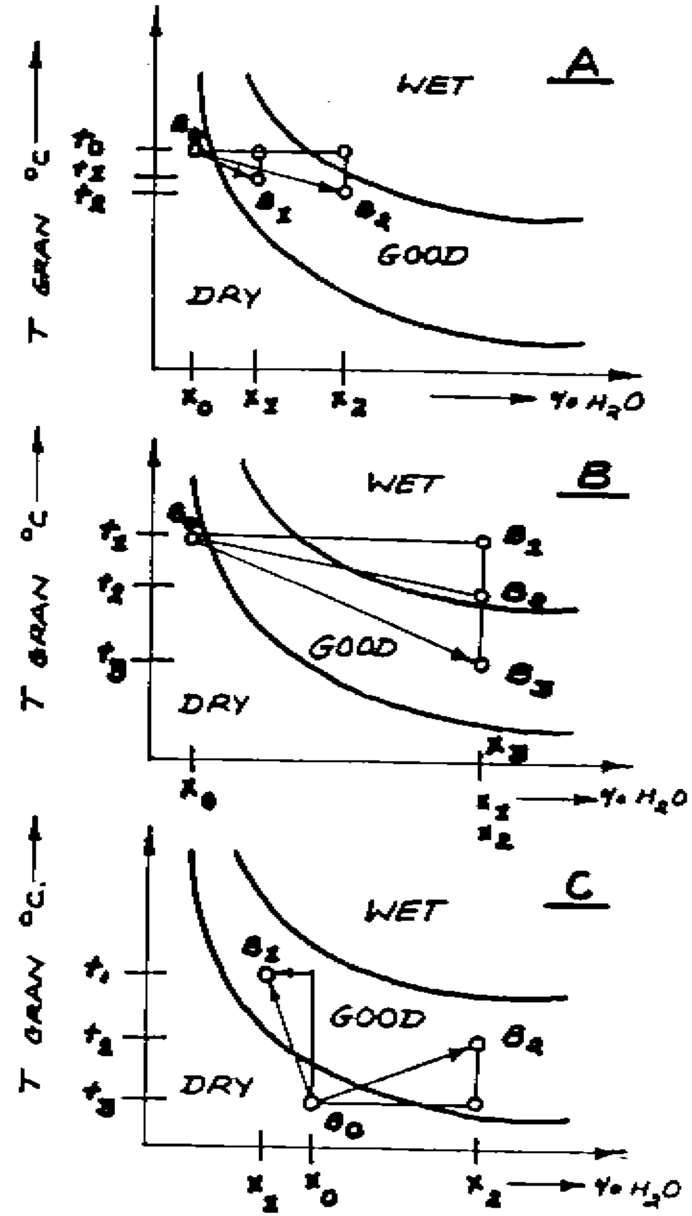

FIG. 3 DRY GRANULATION CONDITION.

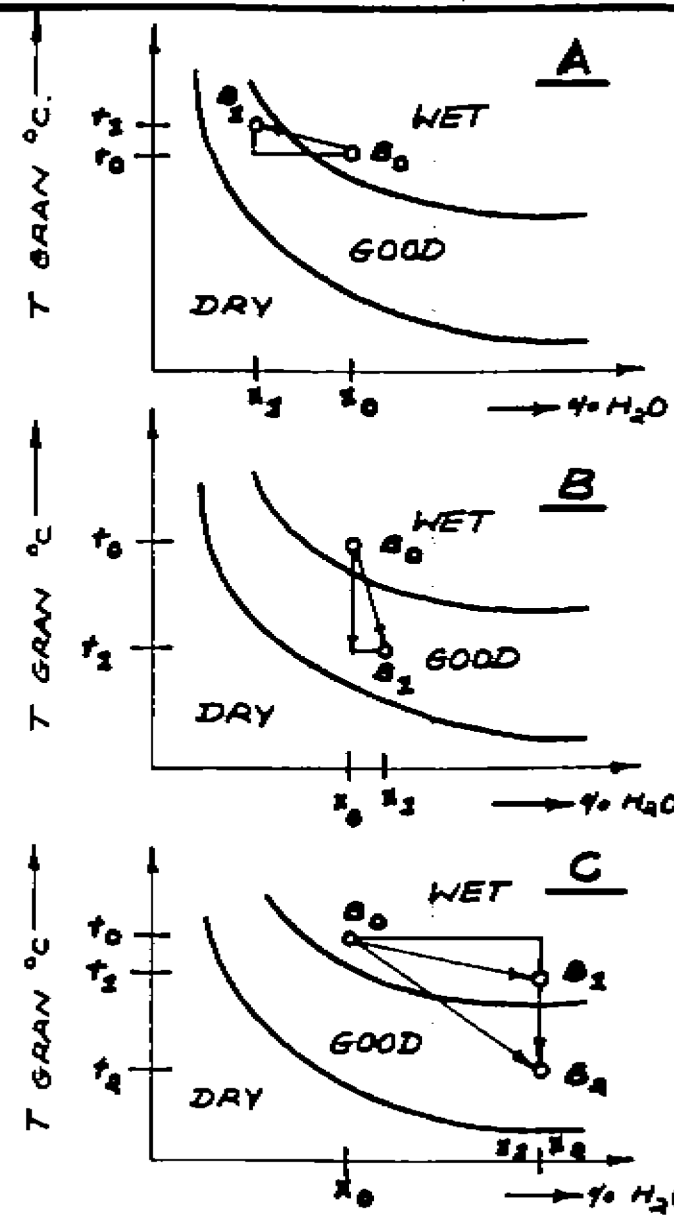

FIG. 4 WET GRANULATION CONDITION