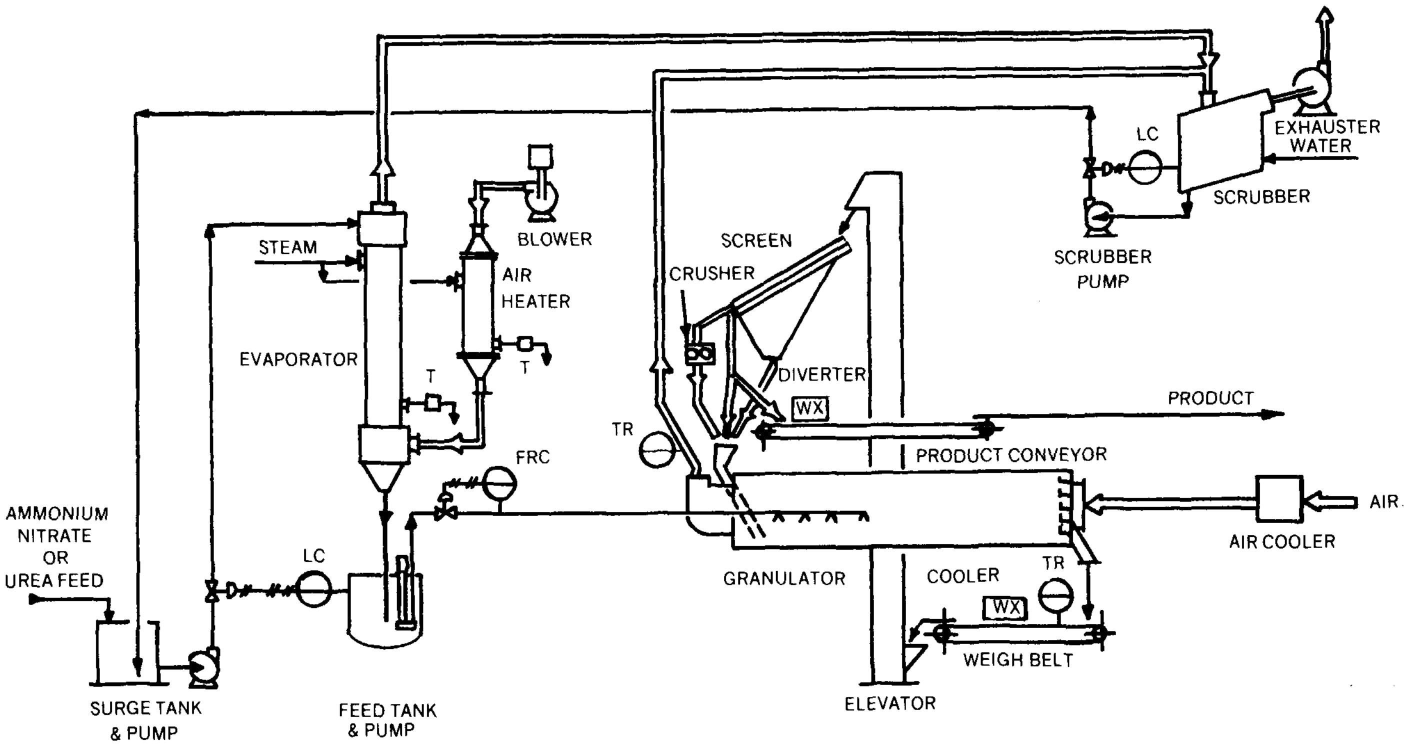

Figure 1. Spherodizer Granulation plant flowsheet.

The Spherodizer Granulation Process

This process permits the production of any desired screen size of ammonium nitrate and urea for bulk blending, and also provides effective pollution control.

R. M. Reed, and **J. C. Reynolds,** C&I / Girdler Inc., Louisville, Ky.

Since the introduction of the prilling process (*1*) for manufacturing granular ammonium nitrate by Cominco during World War II, this process has gained worldwide acceptance for the production of fertilizer grade ammonium nitrate and urea. In the prilling process, a concentrated solution (95% or higher) of ammonium nitrate nitrate or urea is sprayed from the top of a tall tower into a rising stream of air which cools the droplets which, in turn, crystallize to form round solid grains suitable for fertilizer use.

Two problems are inherent in the prilling process. The large volume of cooling air required to solidify and cool the prills entrains dust, creating a product loss and pollution problem if discharged directly to the air. The installation of dust scrubbing equipment on the top of a tall prilling tower is very expensive, as is the duct system needed to bring the air back to ground level for treatment.

The second problem inherent in the prilling process is the regulation of product size. The maximum size prills that can be obtained with either ammonium nitrate or urea is limited by the economics of the tower height required to provide sufficient free fall (70- to 170 ft.) for solidification and cooling of the liquid spray, and the air temperature and flow rate of the cooling air used.

The size limitation factor is particularly serious with urea because of its lower melting point (271°F) as compared with ammonium nitrate (337°F), and its higher heat of crystallization, 104 B.t.u./lb., as compared with 61 B.t.u./lb. for ammonium nitrate. Both these factors increase the difficulty of cooling of the urea as compared with the ammonium nitrate.

Typical ammonium nitrate prills will show over 95% through 6 on 16 Tyler screen size, with about 65% on 10, while urea prills will show over 95% through 8 on 16 Tyler screen size, with about 30% on 10. As will be shown later, these sizes and size distributions are less suitable for bulk blending than the product sizes obtainable by granulation.

Spherodizer Granulation process

Originally developed for the production of granular complex fertilizers, the C&I/Girdler Spherodizer Granulation process (*2,3*) utilizes the principle of accretion, or layering, to build up onionskin-like layers of material on small seed particles. This is accomplished by spraying a slurry or solution onto a rolling bed of solid particles in a rotating drum. The spray forms a coating which solidifies and builds up layers on the rolling particles. The rolling action in the rotating drum tends to keep the granules spherical. The product leaving the granulation drum is screened, with both oversized material, after crushing, and fines being recycled to the granulation drum to serve as nuclei for further granule formation.

This method of granule formation differs from that used in most granulation processes, which depend on the agglomeration, or sticking together, of smaller particles, using a solution or slurry as the binding agent. The agglomeration technique for granulation was found to be unsuccessful for the granulation of ammonium nitrate, as reported by the U.S. Department of Agriculture in Technical Bulletin 912, June 1946, which states that the method is not recommended for the commercial granulation of ammonium nitrate.

However, the granulation of ammonium nitrate and urea has been carried out successfully on a commercial scale utilizing the accretion or layering principle of the Spherodizer Granulation process (*4*). The granular products produced by this process are almost spherical in shape, and have been found to be more resistant to breakage than prills, particularly in pneumatic handling equipment.

The flowsheet for the granulation process, as used with ammonium nitrate and urea, is shown in Figure 1. The first step shown is the final concentration of the 80- to 85% feed from the ammonium nitrate or urea synthesis unit. An air-swept falling film, steam-heated evaporator is shown, which produces a substantially anhydrous melt (99.5%) of ammonium nitrate or urea to be pumped to the sprays. Other concentration methods can be used to produce the essentially anhydrous melt, such as vacuum evaporation or crystallization, followed by the remelting of the dried crystals. However, the airswept evaporation system fits into the process very well, since the evaporator can be located near the ground level, and the effluent air stream can be added to the granulator dust recovery system for effective air pollution control.

The molten 99.5% ammonium nitrate or urea is sprayed through spray nozzles onto the rolling bed of solid particles in the rotating granulation drum. Both granulation and cooling occur in the same drum, which contains a dam to separate the granulation and cooling sections. The dam retains a sufficient bed of granules so that the average particle remains there for a long enough time and contacts the liquid spray enough times to build up several layers per pass. After overflowing the dam, the granules are cooled in the cooling section of the drum by cold air, and passed through the drum countercurrent to the flow of solids. The recycle fines are introduced into the end of the granulation section and provide the seed for granule formation. The ratio of recycle to product is kept at about 2:1, and may be adjusted by diverting some of the product to recycle, if necessary.

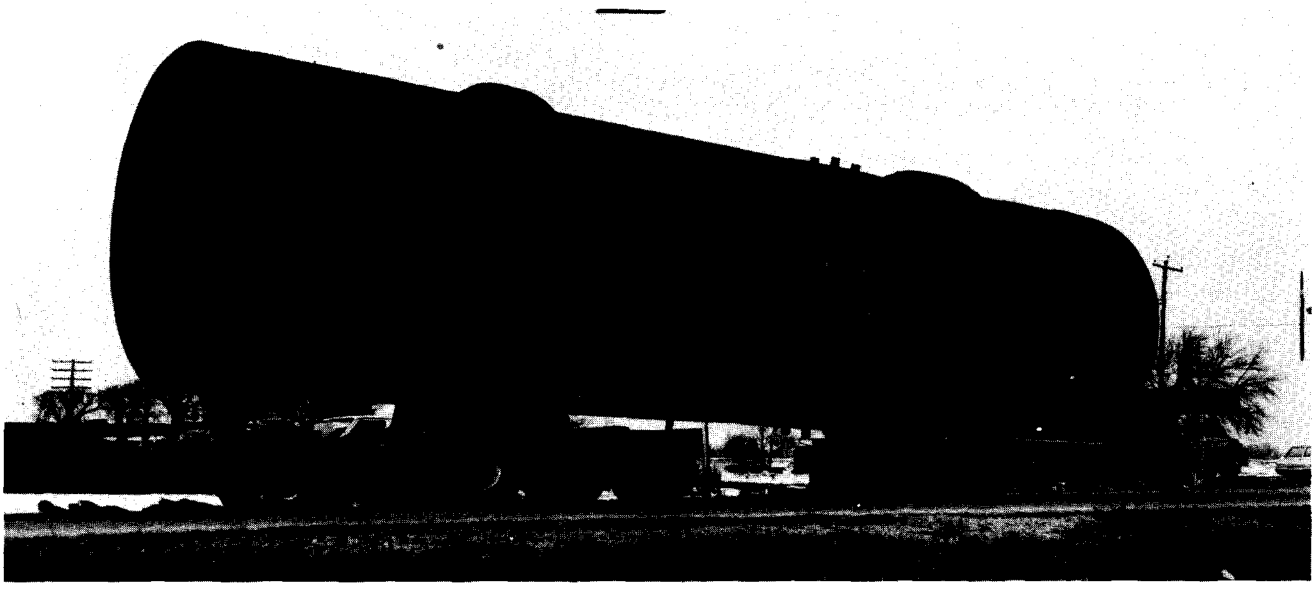

Figure 2. Granulation drum for 300 ton/day ammonium nitrate plant.

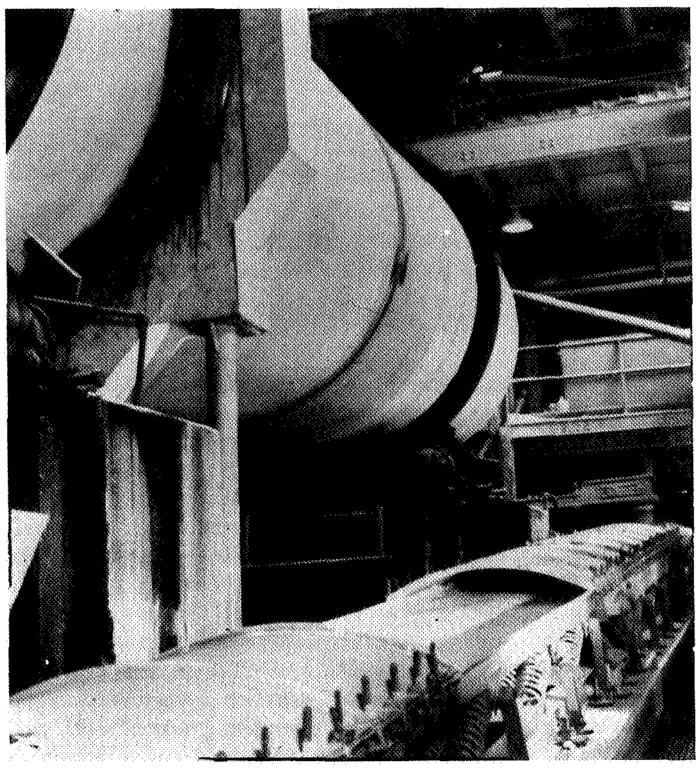

Figure 3. Granulation drum in 250 ton/day urea plant.

By weighing both the product and the output of the granulator drum, the recycle rate can be monitored. The air flow rate is regulated to maintain the desired air temperature in the exit air stream and, at the same time, provide adequate cooling. Dust is removed from this air stream in a Doyle wet scrubber which also scrubs dust from the effluent stream from the airswept falling film evaporator.

The stream of granules coming from the drum passes over a weigh belt to an elevator which carries it up to the screen that separates it into oversize, product, and fines. The oversized material is crushed, and together with the fines, is recycled. The product sized material is sent to storage.

Ammonium nitrate granules will ordinarily require additional cooling because of the high melting point of ammonium nitrate and resulting higher granulation temperature. Urea granules may be sent directly from the screen to storage. The ammonium nitrate or urea solution formed in the wet scrubber is returned to the inlet of the evaporator for reconcentration and granulation.

Figure 2 is a granulator drum for a 300 ton/day ammonium nitrate granulation plant. Since the materials being handled in these drums are essentially anhydrous, and since the depth of bed is so great, there is little or no corrosion problem, and they may be fabricated of carbon steel.

Figure 3 is a view of the granulator in a 250 ton/day urea granulation plant, taken from the discharge end. The oscillating conveyor moving the unscreened product can also be seen, with one section of the cover removed to show the granules. Figure 4 shows the Doyle wet scrubber, which removes dust from the effluent air streams.

The Spherodizer granulation plant is essentially automatic in operation, and operating labor requirements are very small, requiring only part time attention of one operator. The system is easy to start up and shut down, as shown in one ammonium nitrate plant that customarily operates two ten hour shifts, five days a week, during the winter season.

Utility requirements are approximately 550 lb. of steam and 35 kw.hr. of electric power per short ton of granular product, starting with 99.5% melt of either ammonium nitrate or urea. This does not include refrigeration of the cooling air, which may be necessary in locations with high average ambient temperatures, but is not required in many locations. When refrigeration

Table 1. Screen sizes for various fertilizer ingredients.

	Tyler Screen Range, wt. %				
Product	+6	− 6 + 8	− 8 +10	−10 +16	−16
Ammonium Nitrate (AN)					
Low Density Prills	0	6	65	25	4
High Density Prills	0	0	8	89	3
Granules	1	35	54	8	2
Urea Prills					
Uncoated	0	1	17	78	4
Coated	0	0	1	94	5
Ammonium Phosphate					
Nitrate Granules	0	33	55	9	3
Diammonium Phosphate					
Granules	0	42	57	1	0
Triple Superphosphate					
Granules	<1	29	56	14	<1
Potassium Chloride					
Granules	2	36	52	10	0

is utilized, it is used for its cooling effect, rather than for the dehumidification it provides, although the dehumidification aids in maintaining a low moisture content in the granular product. The moisture content may be easily maintained at less than 0.15%, which gives a consistently hard product.

Bulk blending characteristics

The bulk blending of different fertilizer products, such as ammonium nitrate, diammonium phosphate and potash, has become an important operation in the fertilizer industry. The purpose of the bulk blending is to produce a mixed fertilizer of a desired N-P-K formulation that can be stored, shipped, and spread in available commercial equipment without excessive segregation of the various components.

A number of studies have been made on the segregation experienced in the blending and handling of these fertilizers (*5-7*). When products having different size ranges are blended, segregation is likely to occur, resulting in incorrect compositions at the point of use. Such segregation can occur due to the coning effect as granules are poured onto a conical pile. Travis Hignett of TVA reported on tests carried out to study this effect, and found that the greatest single factor in producing segregation was the size distribution of the different materials (*5*). Differences in shape or density had little effect. In testing a blend containing ammonium nitrate, triple superphosphate, and potassium chloride, after pouring the thoroughly blended mixture onto a conical pile, different segments of the pile, nominally 14-14-14, ranged from 19-10-12 to 7-21-17. A similar test with materials well matched in size showed only a very minor spread in composition.

Hignett made the following recommendations to minimize segregation:

"Select materials that are closely and similarly sized.

"When the materials arrive at the plant, transfer them to storage in a way that will minimize differences in particle size from one part of the pile to another.

"Avoid coning of piles or coning in bins or hoppers. Various methods of avoiding coning can be devised, such as special distributors in bins and flexible hoses attached to discharge spouts for filling spreader vehicles.

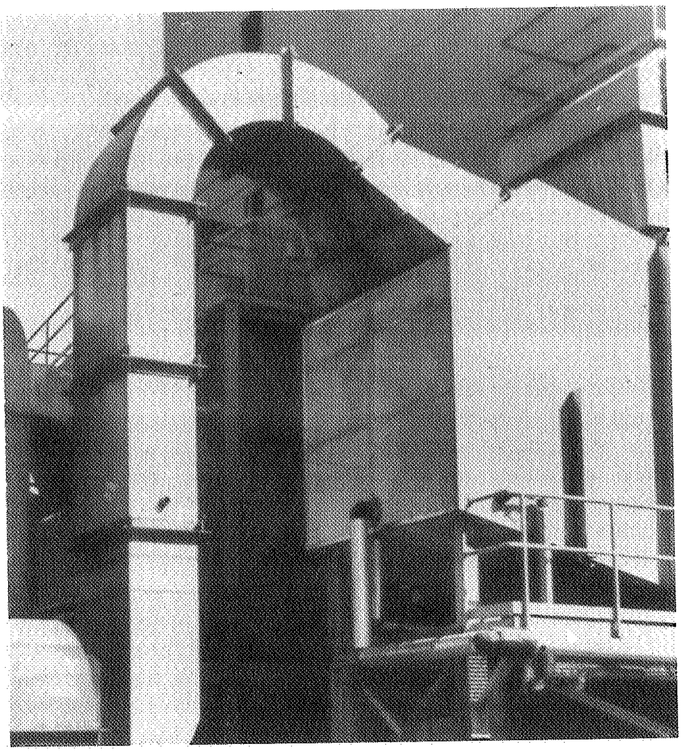

Figure 4. Wet scrubber in 250 ton/day urea plant.

"Minimize handling. Segregation occurs only when mixtures are moved. If possible, move mixtures directly from mixer to spreader without intermediate binning or storage."

The most effective means of minimizing segregation of components in fertilizer blends, as reported by Hignett, is to use materials as nearly the same size as possible,

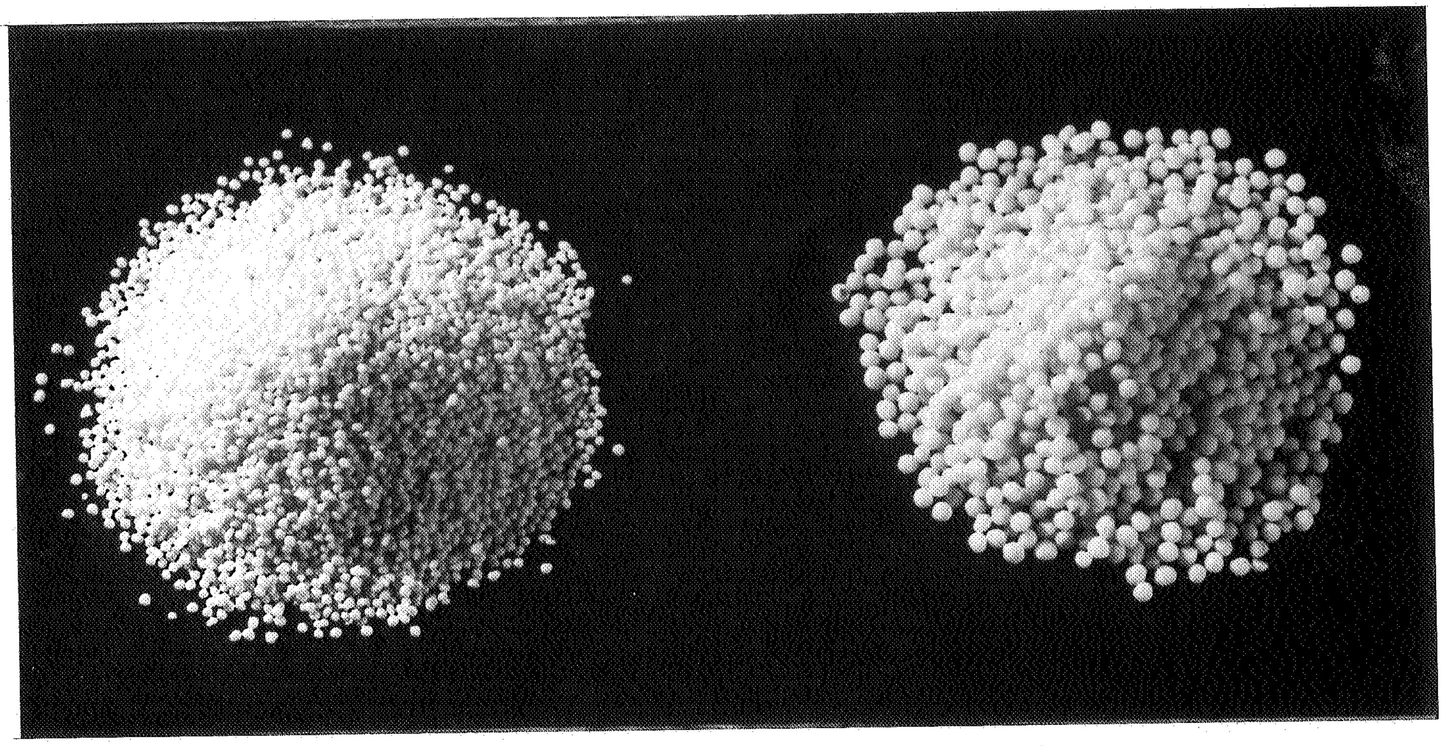

Figure 5. Fertilizer grade (left) and forestry (right) granular urea.

even though they may vary somewhat in density and degree of roundness. He listed the screen sizes (shown in Table 1) for various fertilizer ingredients.

It will be noted that the granular products, with percentages ranging from 85- to 99% in the through 6 on 10 screen size range, are all larger in size than either ammonium nitrate or urea prills, which range from 90- to 97% in the through 8 on 16 screen size range.

Hoffmeister and coworkers at TVA, studying the segregation problem, reported that two materials, both through 6 on 16 mesh, can segregate severely unless each has about the same distribution in the through 6 on 8, the through 8 on 10 and the through 10 on 16 mesh ranges (*6*). Unfortunately, such maldistribution is the case with prilled urea or ammonium nitrate when blended with granular ammonium phosphate, triple superphosphate, and potassium chloride. The ammonium nitrate and urea prills are enough different in average size from the granular products that segregation is likely to occur.

The conclusions of the TVA workers were confirmed by studies reported by C. H. Russell of Monsanto Co. (*7*). He found that a triple 17.7 blend that did not segregate could be made with granular ammonium nitrate, diammonium phosphate and potash, as long as all were closely matched in particle size and with a similar size distribution range. He further concluded that if the materials are closely matched on the coarse end, a great deal of fines can be tolerated, but that if the matching is close only on the finer sizes, only a limited variation can be tolerated on the coarse end.

Finer materials, such as some of the fine potassium sulfate or chloride products,will not remain blended when mixed with granular products. Very coarse materials, such as those mainly through 6 on 9 Tyler screen mesh size must be closely matched in particle size for good blending.

As mentioned earlier, the great height required for prilling towers for ammonium nitrate and urea, plus the large air flow requirements for cooling, has limited the size of these prilled products to a smaller size than is normally produced in the other granular bulk blending materials, which has resulted in serious segregation problems.

Granulated ammonium nitrate or urea, as contrasted with prills, is not limited as to the size range that can be produced. As shown in Table 1, ammonium nitrate granules have a size distribution range the same as that of other commercial granular fertilizer materials.

The product size produced can be regulated as desired by choice of suitable screen sizes. If a larger product is desired, the screen mesh size is increased, and finer granules recycle until they are built up to the desired size. This is illustrated in the production of forestry grade area, as compared with fertilizer grade, as shown in Figure 5.

The forestry grade, with a size range of through 3½ on 8 mesh is particularly adapted to use in the fertilization of forest areas by spreading the fertilizer with an airplane. The larger granules are less susceptible to drifting by wind currents than the fertilizer grade urea. The large forest grade granular urea is produced in the same Spherodizer equipment as the fertilizer grade by changing the screen sizes. This flexibility effectively optimizes the sizing of ammonium nitrate and urea for bulk blending purposes.

Pollution control

As was shown in Figures 1 and 4, the air discharged from the airswept evaporator and the granulation drum is exhausted from the system through a Doyle wet scrubber. This is a high efficiency (about 99.5%) wet scrubber, in which the inlet air stream impinges at high velocity into a pool of solution. Water is added to the scrubber to maintain the solution concentration at about 50%, with excess solution being pumped back to the feed surge tank. The exit air passes through baffles and a separating chamber in the scrubber, and then through a duct to the exhaust blower. With the exhaust blower being located downstream from the scrubber, it receives clean air, and has no problems of dust buildup. Using an exhaust blower also keeps the granulation drum under a slight negative pressure and prevents dust laden air from escaping. Any type of high efficiency wet scrubber could be utilized for this dust scrubbing operation, but the one described here has proven to be very satisfactory for cleaning the effluent air stream. The only other effluent from the plant is the steam condensate from the evaporator and air heater, which presents no pollution problem.

Since all the plant equipment is located near ground level, the ductwork is kept to a minimum. The quantity of air to be handled will be about one-third of that which would be required for a prilling tower, so the dust scrubbing equipment can be correspondingly smaller. The smaller air requirement results from the fact that the air leaving the granulation drum, at about 170- to 190°F, is much hotter than that leaving a prilling tower, and consequently much less is required for the same cooling duty. In the granulation drum much of the initial cooling of the melt is done on contact with the recycled fines, which have been previously cooled efficiently in the cooling section of the drum before they were recycled.

In conclusion, the problems of producing a granular ammonium nitrate or urea product suitable for bulk blending and obtaining effective pollution control have been solved in a practical manner by this granulation process. #

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R. M. Reed is an engineering consultant, specializing in synthetic nitrogen fertilizers, gas purification and hydrogen manufacturing. He holds a number of patents and has published numerous articles in these fields. He obtained a Ph.D. degree at the University of Washington, and retired in 1969 as technical director of C&I / Girdler Inc.

J. C. Reynolds is an engineering specialist for C&I / Girdler Inc. He prepares process design calculations, equipment sizes and specifications, and economic evaluations for various old and new chemical processes. His speciality is urea synthesis and finishing processes. He is also active in synthesis gas generation and purification for heavy chemicals and fertilizers. Before joining C&I / Girdler, he was a research engineer with the Shell Oil Co. He received his B.S. and M.S. degrees in chemical engineering from the University of Louisville.

DISCUSSION

Q. At about a 0.3 or 0.5 % moisture in urea, what is the biuret increase across the Spherodizer?

REED: The biuret increase is probably in the range of 0.2%. The product starting with the evaporator gives a prilled product of 1% biuret, or slightly less. It's in that range.

Q. Can you, with this type of process equipment, produce a typical solid feed grade urea that can be pneumatically handled?

REED: No. This product, so far, has not been adaptable to microprilling. The amount of fine material produced in the unit, as presently operated, doesn't give enough product for that purpose.

Q. Has the scrubber mentioned in your paper been tried on prilling tower stacks, and do you have a plume from your scrubber when used with a falling film evaporator?

REED: To my knowledge, the Doyle scrubber, which was a development of Cominco, and is available commercially at present, has not been used on handling effluent from a prilling tower, although, as far as I know, there would be no reason why it could not be used for this. With urea, and using a falling film evaporator and this scrubber, I have seen the plant, when the temperature conditions were right, operating so that the plume from the scrubber was completely colorless, no apparent steam, and you couldn't tell there was anything going out at all. That, of course, was the ideal from the standpoint of the observer. During different temperature conditions, depending on the concentration of the solution in the scrubber, you may or may not get a mist of steam coming off. I do not have a similar observation with respect to ammonium nitrate, so I can't give any answer on that.