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Development of Compaction and Bulk Blending in Guatemala

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Abstract
Although the NPK fertilizer industry throughout most of the world is still strongly associated with wet granulation processes, other alternatives such as bulk blending and compaction/granulation are now being considered as practical solutions to the fertilizer production problems of developing countries. The DISAGRO group has proven that bulk blends and compacted products can meet the fertilizer needs of the widely diversified agricultural sector of Guatemala. The production plants and marketing plans used by the group have become a showcase for other countries to study and have shown that their success could be accomplished in other countries.

This paper concentrates on the development of the compaction/granulation industry in Guatemala and focuses on the advantages and disadvantages of the process.

Introduction
When I think of the fertilizer market in Guatemala, definitely bulk blends come to my mind because this type of fertilizer has made such an impact on all the agricultural sectors, helping farmers increase their yields and profits. Nevertheless, when I think of the fertilizer industry in Guatemala, compaction comes to my mind because it has revolutionized the fertilizer production in the country and it has also pioneered, at an international level, an NPK production alternative for developing countries.

Because of the simplicity of bulk blending, I would not emphasize it as an industrial process that deserves too much attention or discussion. Nevertheless, it is the flexibility of the process that I value which characterizes it as an agronomic solution for the production of formulas based on the individual crop requirements and characteristics and deficiencies of the various soils. This is of particular importance for a country such as Guatemala where a wide variety of crops are grown at altitudes from sea level to 10.000 feet above sea level on different soils, loose and heavy, acid and alkaline, with rainfall ranging from desert-like to tropical.

I will not devote too much of this presentation to bulk blending since we have at this workshop several respectable bulk blenders who will document the benefits and advantages of this simple blending process. Tomorrow Mr. Mark A. Swisher of the DISAGRO group will discuss the characteristics of the different soils and crops of Guatemala. He will describe the group's successful blending installations, and he will cover the publicity and extension efforts used for the marketing of bulk blends. I know that after his presentation and Thursday's field trip there will be no doubts about the potential of this NPK production method and the success it has had in this country.

I will try to summarize today why the DISAGRO group decided to install a compaction plant, and I will focus on the advantages and disadvantages of the process. I will not discuss in detail the equipment at the plant since I feel that this can be done more effectively during the field trip later this week.

Background
The fertilizer market in Guatemala has almost reached 400.000 tonnes of product per year. Of that total amount more than 50 % is composed of straight nitrogen products like urea and ammonium sulfate. The rest of the market is composed of NP and NPK fertilizers manufactured in Guatemala by bulk blending or compaction and granular fertilizers imported from Europe. The imported products are manufactured by wet (slurry)-type granulation processes. There is also a considerable amount of raw materials used for straight application.

Bulk blends were introduced in Guatemala by the DISAGRO group at the end of the 1970s with a good acceptance from the progressive farmer who found the flexibility of this NPK production method ideal for making formulas based on crop requirements and specific soil deficiencies. This product acceptance and loyalty has been increasing year after year, thanks to the marketing efforts from the group of agronomists. Nevertheless, another segment of the market has never accepted blends, preferring the uniform colored homogeneous NPKs from Europe manufactured by various wet-granulation processes.

After recognizing this, the DISAGRO group started evaluating in 1985 the feasibility of constructing a plant to manufacture a one-color homogeneous fertilizer to penetrate the market not accessible with bulk blends. None of the wet-granulation processes were seriously considered because of the large investment required and because we saw a trend all over the world for the industry to move away from this production method.

The compaction process was considered on the basis of the following considerations: (1) low investment cost, (2) low final cost utilizing standard raw materials and local fillers, (3) simple process, and (4) low operation cost.

After a complete evaluation, compaction was chosen over the traditional wet-granulation process. Several plants were visited in Canada, United States, France, and Germany. Although these plants were compacting potash, specialty-type garden fertilizers, or PKs, they proved to be very enlightening in our design of the plant. The three major manufacturers of compaction machines (roller presses) were contacted and much was learned from them. Once the decision to go ahead with the project was taken, a set (two) of compactors was ordered from the KÖPPERN company of West Germany. The Sackett company of Baltimore, Maryland, was chosen to complete the plant layout and to supply the blending and material handling equipment.

The Plant

The plant of Fertilizantes Quimicos de Guatemala (FERQUIGUA) is located in Teculutan, 125 km northeast of Guatemala City. The raw materials for this plant are imported through the Port of Santo Tomas de Castilla on the Atlantic Ocean some 200 km east of the plant. The building that houses the production facilities was built with prestressed and posttensioned concrete. Cement sheeting was used for the roof and siding. The area under roof is 8.000 m^2, providing storage for more than 25.000 tonnes of raw materials in bulk and 5.000 tonnes of bagged products. The plant was laid out to incorporate room for a future expansion of the compaction system – a second train of equipment identical to the existing plant. The cost for all the civil work including the warehouse was estimated at US $1 million.

The total cost for the two compactors, blending tower (raw material feed system), material handling equipment, mills, screens, and bagging equipment added up to US $1.8 million. I must clarify that because of the new exchange rate of the U.S. dollar with the Deutsche Mark and an increase in price in most of the equipment; today the same equipment would cost around US $2.5 million.

The plant was constructed during 1986 and the first quarter of 1987, a total of 15 months. During the first season the plant produced around 25.000 tonnes and then shut down for the last 2 months of the year for the annual corrective and preventive maintenance program as well as for some corrective design of the dedusting system and other miscellaneous equipment. During 1988 and this year (1989), annual production has exceeded 50.000 tonnes of bagged NP and NPK fertilizers and granular raw materials used for bulk blending. The market for the bagged finished product has been mainly in Guatemala although the plant is also exporting some materials to Honduras. The granular raw materials are produced for the two sister companies involved in bulk blending here in Guatemala, FERTILASA and DISFERSA, as well as for a blender in Costa Rica.

As the fertilizer market in Guatemala continues to grow and with the increased production of granular raw materials for blending, FERQUIGUA could be in the position to expand its production capacity by 1991.

The flowsheet of the plant (Figure 1) starts with a bulk conditioner (1) fed by a front loader. All the raw materials are then transferred by elevators to six storage bins at the top of the blending tower (2). A computer prepares the individual batches, feeding the product into a weigh hopper (3) and then into a 4-tonne rotary blender (4). A second elevator raises the product to a double-row cage mill (5) which grinds the product to a minus 60-plus 100-mesh particle size and discharges it into a primary hopper. The recycle product and the primary feed are then mixed in a double-shaft pug mill (6) where liquids are sometimes added. The material mixture is then passed through magnetic humps and then split into two streams to feed the two compaction lines. Drag chain conveyors regulate the flow into the compactors, thereby ensuring a constant and uniform feed. The compactors (7) convert the fine feed into approximately ½-inch thick flakes ranging from 2 to 10 inches in size which are then transported on a conveyor belt to elevators feeding two double-deck screens (8). The oversize material separated by the screens is then passed through slow-moving chain mills (9). All the undersize material is collected and transported to the recycle hopper with a drag chain conveyor. The finished product is sent via another belt conveyor to the bagging or bulk storage hoppers. Table 1 gives the material particle-size distribution at different locations during the process.

A dedusting system (10) with a fan and four cyclones is located in the middle of the plant. All the dust collected is returned to the process through the recycle chain conveyor. The dedusting system has been simplified and modified to prevent operating problems and reduce required maintenance. Currently we have reduced the number of locations where dust is collected, concentrating on the areas that deal with the finished product. Because of the nature of the production, the dedusting system is now used not only as a means to reduce the dust emissions in the plant, but also as a quality control measure to reduce the temperature of the finished product and remove fine particles left after screening.

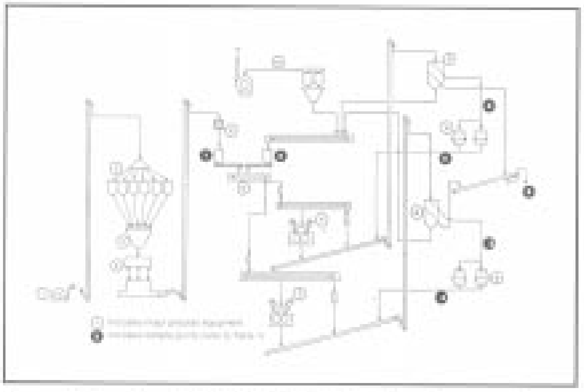

Figure 1: Flowsheet of the FERQUIGUA Fertilizer Compaction/Granulation Plant

Advantages of the Compaction Process

Low Investment Cost/Simple Process

The cost of a compaction plant is substantially lower than any wet granulation plant. Only the simple steam granulation process used in India and the Philippines has a comparable cost. On the other end of the scale, a compaction plant costs almost US $ 2 million more than a bulk-blending plant, nevertheless, with the reduction of cost in the fine and standard (nongranular) raw materials used, the return on investment of a compaction plant could justify the additional investment. The other advantage of the compaction process is the simplicity of the equipment and the process, making the operation and maintenance very straightforward.

Raw Materials

In the production process FERQUIGUA uses the following raw materials: prilled urea, standard ammonium sulfate (AS), fine monoammonium phosphate (MAP), powdered high reactivity phosphate rock, standard muriate of potash (MOP), kieserite fines, boron fines, zinc oxide fines, and ground calcium sulfate (gypsum) from local mines. All these raw materials are also bagged and sold to farmers for straight application.

Having three sources of nitrogen (urea, AS, and MAP), two sources of phosphate (MAP and phosphate rock), and a filler (gypsum) allows great flexibility in modifying formulations to incorporate economic factors based on the price of the raw materials and agronomic factors based on soil analyses and crop peculiarities. For example, a formula for a perennial, such as coffee grown on an acid soil, could use the economical, slow-release phosphate rock as the main source of P_2O_5 and urea, the most economical source of nitrogen.

Although powdered MAP is the best material to compact and improve the physical compaction properties of any formulation, there are economic benefits in using a high reactivity phosphate rock as an alternative source of P_2O_5. Guatemala grows some of its most important cash crops (coffee, sugar-cane, rubber and cardamon) on acid soils having a high phosphorus fixation capacity due to the large concentrations of aluminium, manganese, and iron. The high reactivity

Primary Feed Hopper Below Cage Mill (Point 1)			Recycle Feed Hopper (Point 2)			Entering Chain Mill (Point 3)			Leaving Chain Mill (Point 4)			Finished Product (Point 5)		
Mesh	Retained	Accumula.	Mesh	Retained	Accumula.	Mesh	Retained	Accumula.	Mesh	Retained	Accumula.	Mesh	Retained	Accumula.
6	0	0	6	1.07	1.07	¼-in	74.57	74.57	¼-in	25.75	25.75	6	0.41	0.41
10	0.15	0.15	10	10.11	11.18	4	7.16	81.73	4	9.94	35.69	8	16.94	17.35
14	0.55	0.70	12	6.12	17.30	6	13.38	95.11	6	22.71	58.40	10	67.94	85.29
16	0.60	1.30	14	11.63	28.93	10	3.88	98.99	10	17.94	76.34	12	8.61	93.90
18	1.06	2.36	16	3.72	32.65	12	0.38	99.37	12	5.88	82.22	14	3.38	97.28
20	1.66	4.02	18	13.01	45.66	14	0.30	99.67	14	12.75	94.97	16	1.33	98.61
30	1.91	5.93	20	9.56	55.22	16	0.11	99.78	16	1.51	96.48	18	0.93	99.54
45	13.67	19.60	30	10.30	65.52	18	0.22	100.00	18	3.09	99.57	20	0.46	100.00
60	34.17	53.77	45	23.49	89.01				20	0.43	100.00			
80	25.18	78.95	80	9.32	98.33									
100	13.67	92.62	100	0.37	98.70									

Table 1: Typical Screen Analysis of Materials at Various Points in FERQUIGUA Compaction Plant

phosphate rock, like the one imported from North Carolina, offers the farmer a slow-release source of P_2O_5 with less danger of fixation and at a more competitive cost. In most formulations we include a combination of MAP and phosphate rock which offers a quick water-soluble source and a slow-release source of phosphate. This is comparable to some imported granular NPKs where the P_2O_5 source is only partially acidulated.

Flexibility
Although the plant was originally planned for the production of continuous long runs of the three traditional formulas (15 - 15 - 15, 20 - 20 - 0, and 16 - 20 - 0) for the traditional farmer, the FERQUIGUA plant has now produced more than 25 different grades. Changing grades is not the headache we expected – after stopping the primary feed, all the recycled material can be compacted in a very short time. This flexibility allows for a change in formulation in less than 20 minutes. Small runs of even 10 tonnes can be accomplished to meet a client's order. Production of four or five different formulas in one day is common at the plant, thus minimizing the need for maintaining inventories of a wide selection of formulas.

The only limitation in the formulations has been the urea content. The maximum amount used with success has been around 30 % which combined with the other sources of nitrogen translates into a nitrogen content in the formula of around 21 %. Most traditional formulas used in Guatemala have lower N values but a lot of the new NK bulk-blended formulas used in coffee or in second applications on other crops do have a higher N content. There is no limitation in the amount of phosphate and potash used in the formulations since the compaction of MAP and MOP has been accomplished with very good results. This point brings us to the next advantage of compaction.

Compacted Raw Materials for Bulk Blending
For the DISAGRO group perhaps the most important advantage of the compaction installation has been the capability to produce first class granular compounds for use in their blending operations. This has allowed for substantial reductions in cost by importing powder and fine products instead of more expensive granular raw materials.

Although most granular raw materials are traded at a premium of only US $ 10/tonne above their nongranular counterparts, some specialty products such as boron and ammonium sulfate have a much higher price difference. Granular boron compounds are usually some US $ 150/tonne more expensive than fine equivalents, so now FERQUIGUA imports boron fines to produce a compacted granular material for the bulk-blending plants in Guatemala and even in Costa Rica where an additional trucking cost of US $ 65/tonne is incurred. I want to point out that compacted boron is one of the materials produced with the best physical characteristics, showing a very uniform granule and a higher hardness than most other granular products.

In the case of magnesium sulfate, a blend with MOP and MAP has been designed to improve the quality of the compacted product and to ensure good abrasion resistance required for bulk transportation and blending.

The most important development of compacted raw materials is the grade 4 - 29 - 0. This is a combination of MAP fines, high-reactivity phosphate rock, and calcium sulfate. From the agronomic point of view, this material combines a quick (100 %) water-soluble source of P_2O_5 with a slow-release source thus providing enough phosphorus for the crop's immediate requirement but also ensuring the long-term availability of phosphorus in volcanic soils with a high phosphorus-fixation capacity. From the economic point of view, this raw material allows for a more competitive source of P_2O_5 for the bulk blends to compete with the imported NPKs from Europe which also do not have 100 % of the P_2O_5 in a water-soluble form.

Please keep in mind that in Guatemala, contrary to many other countries, no fillers like limestone or sand are used in the formulation of bulk blends. The 4 - 29 - 0 grade with only 33 units of nutrients and other grades like 14 - 29 - 0 help in the formulation of low nutrient blends like 16 - 20 - 0 which normally require granular raw materials with high costs per unit of nutrient such as triple superphosphate and ammonium sulfate. The compacted compounds enable the use of more cost-effective materials like urea, MAP, and DAP.

Operation Cost
Excluding the depreciation of the machinery, the cost of operating a compaction plant is not much higher than that of a bulk-blending plant. One of our biggest surprises was the low electricity consumption in the neighborhood of 13 kWh/tonne of finished product. With the large electric motors in the compactors our initial estimates were almost four times as high as the observed

value. It is believed that because of the low pressures required to compact urea-based NPKs, the electricity demand is substantially lower than the design estimates.

The most demanding need for labor is in the area of maintenance and cleaning. We fortunately chose concrete for the warehouse structural elements and it has proved to be an economical building system and a maintenance-free construction material. All the floors, stairs, and hand rails are made of wood. This represents savings in the original cost and requires no maintenance. Nevertheless, all the equipment is supported on an extensive system of structural steel which requires, together with the equipment itself, a lot of maintenance.

Unlike a bulk-blending plant where cleanliness is not a problem because of the dust-free granular materials, a urea-based compaction plant presents a considerable maintenance problem. Once the blend is ground down to minus 60-mesh in the double-row cage mill, the hygroscopic nature of the urea converts the material into a troublesome product. The original dedusting system, including ducts, cyclones, and air locks, had to be redesigned because the dust collected rapidly and absorbed considerable amounts of moisture from the air; this clogged the system. Although the plant site at Teculutan is located in a region of low relative humidity, during the rainy season the humidity reaches more than 90 % in the early hours of the morning and this complicates the maintenance operation. Nevertheless, visitors from the fertilizer industry always comment on the cleanliness of the plant.

I recommend that the space distribution of a compaction plant be carefully planned. The air volume in the production area should be minimized to enable the implementation of economical ventilation and dehumidifying systems.

Market Acceptability

Going back to the finished NPK products, I have found that the most common doubt about this production method is the market acceptability of the product. It is obvious to the farmers that the particles are not identical to the spheres produced by wet granulation that they are used to seeing. The appearance of the compacted product initially produced by FERQUIGUA showed that it was made up of small granules including a high percentage of 16-mesh particles. During the last season the screens were changed to produce larger particles (70 % greater than 10-mesh) with only 20 % passing a 16-mesh screen. This modification helped to ensure better acceptability of the product.

We all know that the agricultural sector in any country is very conservative and does not like to accept changes in practices, especially changes in the physical appearance of the fertilizer or even the bag. Nevertheless, DISAGRO has managed to maintain a strong market position with bulk blends and compacted fertilizers by using marketing strategies based on agronomic facts. The ultimate goal has been to educate the farmers since we knew that any farmer who understands the necessity of a soil analysis, the importance of the different nutrient requirements of the crops, and the benefits of the different raw materials well take advantage of the flexibility of bulk blends and compacted fertilizer in designing a well-balanced fertilizer program. With the use of an extension agronomist and test plots, every day more farmers are beginning to use more flexible formulas instead of the traditional but not necessarily optimum 16-20-0 and 15-15-15 formulas.

Conclusion

Bulk blending and compaction have allowed the DISAGRO group to supply the Guatemalan farming sectors with a wide selection of formulas at a competitive cost to meet their agricultural needs and personal preferences. I believe that for many developing countries these two NPK production methods could represent a feasible solution to their fertilizer needs. Several companies represented at this workshop are currently taking a close look at these production alternatives and I hope that the workshop proves useful in answering some of their questions.

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