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Production and Marketing
of Compacted NPKs in Switzerland:
Rationale and Results

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Introduction

Ladies and Gentlemen, I want to thank IFDC for the invitation to speak at this workshop. I was asked to report on various aspects of our 18 years of experience in fertilizer compaction. At the beginning I would like to say some words about the development of fertilizer production in our company. What we have today is the result of decades of development. On one hand, it is gratifying to report on the results of such developments – so not everybody must start again from scratch – but, on the other hand, it is also dangerous to transfer know-how if the reasons for particular solutions are not clearly described. The latter is the reason for seminars like the one we are now attending.

Development of Fertilizer Production in CFU

The development of fertilizer production in our company (CFU) is shown below.

- 1883 – Production of superphosphates was started at CFU more than 100 years ago. The prime reason was to boost use of sulfuric acid. Shortly thereafter, mixed fertilizers were added to the program.
- 1938 – First tests were carried out with wet granulation because requirements of the farmer in regard to easier application increased and the appropriate technology was available.
- 1971 – Stepwise conversion of the plant to a compaction process was begun. The conversion was made in steps because, at that time, we were not yet able to compact all mixed fertilizer formulations. This stage was finally reached in 1978.
- 1987 – The bagging operation was changed over from hand bagging to a fully automated bagging and palletizing system. This step was taken because personnel were no longer available for hard work and the bagging quality had to be improved.

Changeover From Wet Granulation to Compaction
This move became necessary because important raw materials, DAP and urea, could not be processed in the old granulation plant. Since these raw materials were economically priced, a method for the granulation of mixed fertilizers with high nutrient content based on DAP and urea had to be found. Of course, other considerations were also involved in the choice of dry granulation by compaction. Some of the other major considerations are summarized in the following paragraphs.

Advantages of Compaction Over Wet (Slurry) Granulation

	Advantage	Comments
1.	The compaction process is suited for relatively small production capacities	Slurry-type granulation is only economical in large systems
2.	No environmental concerns are encountered (air or water)	Pollution control is quite expensive in slurry-type granulation plants
3.	The product has very low caking characteristics	Great problems occur with wet granulation if drying is not complete
4.	Compaction/granulation has great flexibility in regard to the use of different raw materials and change-over to different formulations	Flexibility is important if many different types of mixed fertilizers must be made. Changing grades in a wet-type granulation plant requires considerable time
5.	The compaction process conserves energy	Because this was really not considered at the time of the change-over, no data are available. However lower energy consumption can be assumed with compaction.

Of course, compaction not only offers advantages over wet granulation, but some disadvantages also exist. They are mostly due to the production of irregular (split and crushed) particles as compared with more or less spherical granules produced during wet granulation. Some of the disadvantages of the particle shape of compacted products are summarized as follows.

1. Higher abrasion, therefore more fines and dust in the fertilizer
2. Somewhat reduced flowability
3. „Rougher feel“ in case of application by hand
4. Uncommon appeal; possible problems with acceptance by the farmer

Eighteen years ago these disadvantages were not so obvious as they have become today. Some efforts had to be made to reduce the importance of these disadvantages. For example, product is now being rescreened and an antidusting agent is applied. On the other hand, some of the seemingly existing disadvantages could probably be eliminated by intensive discussions with the user. After all, perfect solutions cost money and are ultimately paid for by the farmer.

The Compaction Plant of CFU

Figure 1 shows the flowsheet of our plant. This schematic diagram will be briefly explained and detailed information will be given about each

individual piece of equipment within the plant and its importance. Also, some special characteristics of our plant will be explained. While all this is being done, possibilities for improvements will also be pointed out.

The heart of the plant is the roll press with a capacity of approximately 18 tph, including recycle, or about 10 tph of product. All other plant equipment is sized to match this capacity. The system is operated by two people. One supplies the fresh feed materials by front-end loader (1) from a nearby storage facility (Figure 1). It is this person's duty to carefully meter each component into the weigh hopper (2) according to the formulation to be processed. The second person controls the entire plant and optimizes the performance of each piece of equipment. Normally the plant is interlocked so that if one piece of equipment fails the entire plant will shut down. However, it is also possible to operate each piece of equipment manually and independently which is important when testing new formulations.

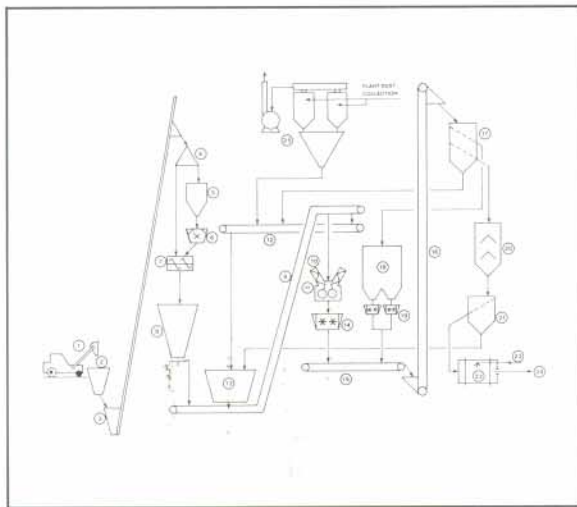


Figure 1: Flowsheet of the CFU Fertilizer Compaction/Granulation Plant

From the weigh hopper (2) the raw materials are transferred into a skip hoist (3) which raises them to a diverter gate (4). By means of this diverter gate, it is possible to send the raw materials into a surge bin (5) and finally into an impact mill (6). Discharge from the impact mill goes to a mixer (7). It is also possible to shift the diverter gate so that material leaving the skip hoist (3) is sent directly to the mixer (7).

After the mixer the material is stored in a silo (8) from which the appropriate amount is dis-

charged by a rotating disk into a drag conveyor (9) and fed by feed screws (10) into the roll press (11). In order to keep the feed screws fully loaded, a slight excess of material is added to the drag conveyor (9). This excess is transferred to another drag conveyor (12) which carries it to the surge bin (13). From this surge bin it is returned to the roll press.

Sufficient capacity of silo (8) makes it possible to operate the compaction part of the plant on a continuous basis while the front end (formulating section) of the plant is being operated on a batch basis.

In the roll press (11) the raw materials are compacted into a solid sheet which is sent to a flake breaker (14) where it is broken into pieces that can be easily handled. By means of another drag conveyor (15) the broken material is transferred to a bucket elevator (16) which raises it to a double-deck screen (17). Undersize particles (recycle) are sent to the surge bin (13) and later returned to the roll press. Oversize material is transferred to a silo (18). These large particles are recrushed in a secondary crusher (19) and returned to the double-deck screen (17) by way of the drag conveyor (15) and the bucket elevator (16).

Product size material is first stored in a curing bin (20) and then rescreened on a single-deck screen (21) to remove any fines before being transferred to a rotating drum (22) where it is treated with a de-dusting agent (23). From the drum the conditioned product is transported to bagging and palletizing (24).

Dust from the dust-collecting system (25) is returned to the roll press via the surge bin (13) and the drag conveyor (9).

Detailed Description of the Equipment and Explanation of Special Plant Characteristics

Raw Material Feed System

A first speciality of our plant is the feeding of raw materials by frontend loader and the individual weighing of each component by the operator of the machine; i. e., there is no automatic batching. The reasons for this design are that 20 years ago, when the investment decision was made, it was felt that the cost of automatic batching was prohibitively high for the envisaged plant capacity. We might have a different opinion if, today, a new plant were being designed. Of course, we

do maintain good control of the formulation by recording the result of each individual weighing step.

A large number of different raw materials is used in the plant to produce a multitude of formulations.

We feel that it is important to be able to crush some of the feed materials while sending others directly to the mixer. This is due to the fact that some raw materials must be reduced in size while others (e. g., super-phosphate) should not or cannot be crushed. In any case, it is desirable to obtain the best compactible feed to the roll press. Therefore, from the point of view of economics, it is important to crush as much feed as necessary, but avoid as much unnecessary crushing as possible. The roll press feed should contain a high percentage of particles between 0.1 and 1.0 mm in size and not too much dust.

The Compaction Machine (Roll Press)

As already mentioned, the roll press is the heart of the entire plant. The sufficient and continuous feeding of the press with material is an important function of plant operation. Good compacted sheet is produced only if the roll press never experiences starved feed conditions. Sufficient feeding is guaranteed by supplying an excess of material to the drag conveyor (9) to ensure that a small (trickle) overflow passes on to the conveyor (12) from which it is returned to silo (13). This ensures that the roll press feed screws are always full.

Furthermore, it is important to maintain a uniform composition of the materials fed to the roll press (fresh material, recycle, and dust from the dust collection system) because the compactibility of each component may be quite different. At CFU we do not have a mixer to homogenize the blend of these materials because we feel that the mixing action of the drag conveyors and the feed screws is sufficient. It is important, however, that the components, particularly the dust, are metered continuously and uniformly into the material flow system.

The feed screws play an important role in feeding the roll press. They force material into the nip between the rolls and thereby cause a certain amount of predensification (removal of air). Experience has taught that operation of the feed screws is critical especially if smooth-surfaced rollers are used.

Increasing the feed pressure to improve compaction may result in the opposite. Additional heat caused by friction may, for example, melt urea which further reduces the grip of the rolls on the material. The introduction of "waffle" surfaced rolls remarkably improved the ability of the rolls to pull material into the nip. A good grip of the rolls on the material is of utmost importance for enabling a press to produce good, dense sheets across the entire width of the rollers.

Particle Size

The influence of particle size on compactibility has already been mentioned in connection with discussion of the impact mill. Too much dust may produce problems caused by entrapped air that must be removed during the compaction process.

Moisture Content

Another important parameter is moisture content. To reduce the tendency to cake, it is always preferable to have the smallest possible moisture content. However, often, a small amount of moisture in the feed improves its compactibility. This benefit may be obtained with moisture contents as low as 0.2% for many raw materials, particularly if relatively large amounts of dust are present. Such a low moisture content does not result in increased caking. Moisture can be added by use of moist raw materials or by spraying water into the mixer. Moisture may also cause problems with feed materials exhibiting extreme hygroscopic or thixotropic characteristics (the case with urea and superphosphate). By varying the relative amounts of these materials (urea or super-phosphate) in the mixture, surprising and often favorable results can be obtained.

Raw Material Storage

In this context it should be mentioned that different relative humidities in the storage area can already warrant modified operating conditions. Therefore, it is most important to protect hygroscopic materials from high humidity. Hygroscopic raw material may not only cause problems during compaction but, alone or in combination with other fertilizer components, such materials sometime cause extreme corrosion problems. For that reason, the CFU compaction plant is located in a closed, heated room in which the relative humidity is kept below 60%. Under these conditions corrosion remains within acceptable limits. The possibility of air conditioning is particularly desirable at times when the plant is shut down.

Product Curing and Hardening

Coming back to compaction, depending on the composition of the fertilizer, the sheet leaving

the roll press may be instantaneously hard and strong or it may be relatively soft. However, after some widely differing periods of time, curing (hardening) takes place. Among the 30 formulations produced at CFU some exhibit below standard particle strength. Nevertheless, they are produced if the compacted granular product offers agronomic advantages.

The plant must not produce products that are merely easy to manufacture but those that the farmer needs and make sense agronomically. Even if a product's quality does not meet the ideal requirements, the best possible granular fertilizer is made from the particular raw materials available. Intensive consultation with the farmer helps to support the supply of such products.

Plant Capacity Factors

The net capacity (product) of a compaction/granulation plant depends on the following three important plant components.

Plant Component	Criteria
1. Roll press	Amount and quality of sheet leaving the press
2. Crusher	Type of crushing mechanism and yield, i. e., ratio of product-to-recycle
3. Screen	Range of particle size distribution and efficiency of screening

A discussion of these factors follows.

Roll Press

The amount and quality of the compacted sheet are related to each other. Thin sheets have a higher quality than thick sheets, because a higher average pressure is exerted throughout the cross section of the thin sheet than on the thick sheet. The interior of a thick sheet is not pressed as firmly as the surface. This means that high capacity due to thick sheets does not necessarily result in high net capacity because the amount of recycle may be disproportionately high. Normally, we prefer to operate with relatively thin sheets; the product quality is better and the total system, particularly the crushers and screens, is less loaded.

Crushers

In the CFU plant crushing takes place in differently sized disk-type roller mills. The use of another crushing mechanism (for example, an impact mill) is out of the question for the generally soft sheets. The flake breaker and secondary mills feature differences in disk diameter, spacer thickness, and gap between the rollers.

Evaluation of Crushing Efficiency – For the evaluation of breaker (crusher) performance the following criteria can be used:

- Ratio of product to recycle (yield)
- Oversize reduction (secondary crushing)

These two values are determined by screen analyses before and after the material passes through the crusher. An example of typical crushing efficiency data follows.

Particle size, mm	0-2 (recycle)	2-5 (product)	>5 (oversize)
Percentage			
– before crusher	3	15	82
– after crusher	23	39	38
– Difference	20	24	44

$$\frac{\text{Product}}{\text{Recycle}} = \frac{P}{R} = \frac{24}{20} = 1.2$$

$$\text{Oversize reduction} = \text{OR} = \frac{44}{82} \times 100 = 54\%$$

Evaluation criteria:

Value		Evaluation
P / R	OR (%)	
< 0.8	< 40	bad
0.8	40	unacceptable
1.0	50	acceptable
1.2	60	good
> 1.2	> 60	very good

Both values should be as high as practical. As much product as possible must be made with as little fines (recycle) as feasible, and secondary crushing must be efficient to avoid overloading of the internal loop. This goal is best reached if the secondary breaker design is adapted to produce product-size particles. A finer product (for example, 1.5-3.5 mm which corresponds to CFU's lawn and garden fertilizer) requires a smaller spacing within the breaker than a coarser one (for example, 2 - 5 mm).

Optimization of sheet crushing is very important but also very demanding. After many years of experience, we at CFU still see possibilities for improvement which, unfortunately, are not

always financially feasible in our old plant. In case of a new plant, the following items should be considered:

- Possibility of curing the product before it is crushed
- Installation of extra capacity (oversized) crushers to avoid overloading
- Crusher dimensions must be compatible with the feed size

Screening

CFU uses a Rhewum high capacity vibrating screen with a slope of the screen deck (adjustable) of approximately 36°. The double-deck screen is relatively easy to clean and maintain. During operation cleaning is accomplished automatically by variable frequency vibration. Particles which are stuck in the meshes of the screen are removed. Nevertheless, depending on the type of fertilizer, more or less frequent manual cleaning of the screen cloth is also necessary. A thin coating of fertilizer builds up around the screen wires reducing the size of the mesh openings. This buildup cannot be removed by vibration. Crust formation shifts the product particle size distribution towards a finer range. If the wires of a screen with 5-mm mesh openings are coated with 2/10 of a millimeter, the open area is reduced by 15% and particles in the size range between 4.6 and 5.0 mm no longer pass through. The same crust formation on a 2-mm screen reduces the open area by 36% and the final product becomes much finer.

While a reduction in yield can be temporarily tolerated if the upper particle size is shifted towards a somewhat smaller dimension, the increase of finer particles and dust in the product is not acceptable. For that reason, CFU has introduced the practice of rescreening.

Particle Rounding and Dedusting

Shortly after starting up our plant, we found that particular attention must be given to the improvement of particle shape. The irregular (crushed) particles had some disadvantages when compared with round granules normally produced with slurry (wet) granulation. At the same time, market requirements became more stringent. The most important requirements were directed towards particle rounding and dedusting.

Particle Rounding – On the basis of extensive testing, a mechanical rounding of the crushed material does not seem to be feasible; to produce round particles by attrition, a large and expensive

rotating drum with long retention time is required. If the crushed particles are hard, extremely fine dust is produced by abrasion. If they are softer, fertilizer crystals and individual material components are broken off thus producing weak spots in the granule and this results in massive degradation. The latter particularly occurs if the raw materials are not finely ground prior to compaction.

In one test five persons who handled different fertilizers after the products had been tumbled in the rotating drum for 10 minutes did not report any significant differences in texture or behaviour between untreated and treated material. Loosely attached particles are more easily removed by rescreening.

Dedusting of the Crushed Particles – Because the granular fertilizer is being produced by crushing, each particle is more or less covered with dust. In a test employing a centrifugal fertilizer spreader, it was found that dusting during spreading of the fertilizer is better suppressed by applying dedusting agents, which prevent new growth of dust, than by air-dedusting the granules during production. Therefore, during the past years, our aim was directed towards the use of most effective dedusting (dust suppressant) agents. Such materials are normally composed of complex mixtures of waxes and oils. Good dedusting agents do not penetrate into the fertilizer particles but coat the surface and, therefore, are effective over long periods of time. This is particularly true for agents containing relatively large amounts of wax. Since uniform application of such agents onto the surface of the fertilizer is difficult, the efforts of CFU are directed towards continually improving the treatment method.

Plant Investment and Production Costs

Investment Cost

Investment costs are primarily influenced by the extent of equipment installed to obtain higher than normal product quality and automation. We estimate that, to build a new plant from front-end loader to 10 tph product, ready to be bagged but without a building, an investment of approximately US \$ 3.5 million (1 US \$ = 1.65 Swiss francs) is necessary. This estimate is based on the assumptions shown in Table 1.

If procurement is limited to the essential plant components, a less sophisticated plant can be built; such a system would still be able to produce acceptable granular fertilizer at a lower cost.

	US \$
Cost of the plant in 1971	910,000
Improvements and additions made since 1971	1,400,000
30% inflation factor (approximate)	690,000
Improvements not yet made in CFU's plant (e. g., automatic batching)	500,000
TOTAL (1989)	3,500,000

Table 1: Estimated 1989 Investment Costs for a 10-tph Plant (Product)

Production Cost

At CFU the total production cost per year (not including raw materials) amounts to approximately US \$ 620,000. The distribution of this total cost is shown in Table 2.

In case of a new plant, operating costs are higher because the higher interest and amortization figures can only be partially offset by lower costs of maintenance and labor. We estimate an annual production cost of approximately US \$ 810,000 (not including raw materials); the percentages can be assigned as shown in Table 2.

	Existing Plant ^a	New Plant ^b
	(% of total annual cost)	
Interest	6.6	13.0
Amortization	20.3	43.2
Labor (operation)	34.9	24.7
Maintenance Materials	10.6	4.3
Maintenance Labor	17.6	6.8
Electricity	8.4	6.8
Steam/Oil	1.6	1.2
TOTAL	100.0	100.0

a. Interest and amortization are based on a book value of US \$ 900,000
 b. Based on a new plant cost of US \$ 3.5 million. Interest equivalent to 6% of 50% of investment. Amortization based on 10% of investment.

Table 2: Distribution of Production Costs for a 10-tph Plant (Product)

Of course, it would make sense to compare these costs with other expenditures for production of multicomponent (NPK) granular fertilizers. It must be realized, however, that the actual raw material prices, the nutrient content of the fertilizer, the annual capacity, and other factors play an important role. An example of the typical CFU cost distribution is shown in Table 3.

At CFU, the relatively high costs for administration and advertising are due to the great competitiveness of the market. The costs are also high because of the intensive services we render the

user which, in today's environment, are necessary for economic and ecologic reasons. Since, in Switzerland, farm sizes are small (Table 4), the cost for consultations compared with the amount of fertilizer used is high. With this structure of medium- to small-size farming, fertilizer sales are mostly handled by agricultural cooperatives and private dealers. There are no direct sales from the manufacturer to the farmer.

Cost Component	% of Total
Fertilizer raw materials	60
Production costs	6
Bagging (material & labor)	7
Administration and advertising	8
Other (storage, laboratory, and overhead)	19
TOTAL	100

Table 3: Distribution of Total Cost of Fertilizer Production at CFU

Type of Farming Operation	Number of Farms
Full-time farming – Average farm size of 15.4 ha	70,000
Part-time farming – Average farm size of 2.0 ha	50,000
TOTAL	120,000

Table 4: Structure of Farming in Switzerland

Raw Materials and Products

Because of the economic and ecologic requirements for today's fertilizers and the conditions imposed on their use, the number of different raw materials used is large as shown in Table 5.

Nitrates, an important nitrogen source, are missing in this summary. For safety reasons we are not using any nitrates in the compaction process. In case of a need for nitrates as a component in mixed fertilizers, we are employing bulk blending for manufacturing these products.

Through the years we were repeatedly confronted with the problem of compacting organic waste materials, either alone or together with mineral fertilizers. It is our experience that roll presses are not very well suited for this task. Such materials are better handled with pelletizing machines. It should be mentioned also that the importance of this segment of the fertilizer market is not high, because of the low nutrient content of such organic wastes as compared with mineral fertilizers.

Nitrogen	Ammonium sulfate Urea Urea derivatives
Phosphates	DAP MAP TSP Superphosphate (SSP) Phosphate Rock
Potassium	Raw potash KCl – 40% K ₂ O KCl – 60% K ₂ O Potassium sulfate – 50% K ₂ O Patentkali 30.7® Kieserite Calcined magnesium sulfate Dolomite Limestone
Others	Sodium chloride Borax Calcium borate Organic waste materials Trace elements (for example, sulfates of Fe, Cu, Mn and Zn) Fillers (Bentonite and sand)

Table 5: Raw Materials Used in Compaction/Granulation of Fertilizers at CFU

CFU's Fertilizer Manufacturing Program/Product (Market) Requirements

As mentioned earlier, CFU manufactures a large number of fertilizer products which are formulated to meet the requirements of the soil, the farm, and the crop. In total, more than 30 different products are being made. They are basic PK-fertilizers and formulations with high nitrogen content as well as special grades for different crops (for example, wheat, potatoes, beans, corn, and rape seed). A listing of CFU's fertilizer manufacturing program (products) is shown in Table 6.

The reasons for the multitude of fertilizer formulations shown in Table 6 include the following:

1. Based on soil analysis and farming method, different nutrient ratios and contents are required.
2. Nitrogen must be supplied when needed and, if possible, in steps. Because of nitrogen losses and to avoid the contamination of groundwater with nitrates, this requirement has become particularly important.
3. Different crops have various needs for boron and other trace elements.
4. Some crops are sensitive to chlorine; therefore, some formulations must be chlorine free.
5. Some crops need sulfur, for example, rape seed.
6. For some soils fertilizers should be combined with soil conditioners, for example, our MONTI-

SAN product which contains 16% calcium for acidic soils.

7. Finally, the farmer requests the most cost effective NPK fertilizer in relation to unit weight or nutrient content.

	Nutrient Content						
	N	P ₂ O ₅	K ₂ O	Mg	B	Cl-free	Other
	%	%	%	%	%	%	
Foskal 1	–	15	30	2			
Foskal 2	–	20	20	2			
Foskal 3	–	11	33	2			
Foskal 7-35	–	7	35	4			
Ammonfoskal	–	6	12	18			
Ammonfoskal 1	–	8	20	30			
Ammonfoskal 2	7	5	30	2			
Ammonfoskal 3	8	8	20	2			
NPK Uetikon	13	13	26				
Epidor	13	13	26	1.5			
Montisan	5	5	15	2			16 Ca
Patador	10	8	24	2	0.05	50	
Carodor	8	10	30	2	0.3		0.2 Mn
Colzador 1	5	15	25	2	0.3		5 S
Colzador 2	–	15	25	2	0.3		5 S
Colzador 3	8	16	18	2	0.3		6 S
Zeador 1	14	8	24	2.5	0.1		
Zeador 2	5	10	26	2.5	0.1		
Mulkafos	–	12	20	3	0.3		
Mulkafos N	6	12	20	3	0.3	50	
Mulkafos N without B	6	12	20	3		50	
Mulkafos S	12	10	20	3	0.3	100	
Vitafofos	–	10	20	3		100	
Vitafofos N	5	10	20	3		100	
Vinosan	10	10	20	3		100	
Suplesan 1	20	8	8	2			2 each Na, Mn and Cu
Suplesan 2	15	8	8	3	0.3		
Suplesan 3	10	5	10	5		100	
Promosan	25	8	6				
Agrisol	12	6	18	2	0.1	100	Includes Mn, Cu, Mo and Z
Fumdor	12	6	22		0.1	100	Contains NO ₃ -N

Table 6: CFU's 1989 Mixed Fertilizer Program

Today, not only the large farmers with acreages of 40 ha or more but all of them are being trained and required to fertilize with just the right amount of nutrients. The general rules for "just the right amount of fertilizer" are shown below.

1. Nutrient consumption by the crop. Agronomic test stations are providing standards.
2. These standards need to be adjusted according to the soil analysis.
3. From the adjusted standards the following inputs must be subtracted:

- Nutrients supplied by on-farm fertilizers (solid and fluid manure)
 - Nutrients supplied by waste fertilizer materials (municipal waste)
 - Nutrients supplied by crop residues after harvest.
4. The value resulting from this exercise defines the nutrient content which must be supplied by mineral fertilizers.

Among the multitude of fertilizers in the CFU manufacturing program, normally an acceptable formulation can be found. If not, CFU is willing to produce special formulations if at least 50 tonnes of a single type of fertilizer is ordered. The foremost goal is customer service and satisfaction.

Acceptance of Compacted Fertilizers

Acceptance of the compacted (irregular) fertilizer granules was not considered a problem 20 years ago. At that time, the switch to compaction was necessary for other reasons as previously described.

During subsequent years, certain difficulties evolved. At first, the competition used the alleged negative characteristics of the compacted product to promote their round product particles and discredit compacted fertilizers. In the meantime, farmers have become used to the product shape so that good compacted fertilizers with narrow particle size distribution and little dusting (after treatment with appropriate dedusting reagents) are readily accepted if the price is right. Price advantages are normally more important than particle appearance.

Granular fertilizers are normally distributed in the field with a centrifugal spreader. When crushed (compacted) products first became available, they were investigated and compared with products that contained rounder particles. It was found that, if the particle size distribution is narrow (2 - 5 mm) and the spreader is adjusted correctly, compacted fertilizers distribute as well, and with the same coefficient of variation, as rounded granular particles. Because the flowability is slightly reduced, the feed opening on the spreader must be adjusted to a somewhat larger cross section to achieve the same rate of application.

CFU has no experience relating to the accuracy of spreading bulk-blended fertilizers. However, it

can be assumed that, if each component features identical particle size distribution and the specific mass of all particles is essentially the same, good distribution can be obtained. However, those preconditions are not always fulfilled.

The reasons why bulk blending is not being used in Switzerland follow:

1. Farmers may not accept the product because its lack of homogeneity is easily visible. There is widespread belief that the correct ratio of nutrients in each particle is important.
2. Mixed fertilizer manufacturers must be concerned about the possible lack of availability and the higher price of fertilizer components that are needed for producing good quality bulk blends.
3. Because of the large number of different formulations presently being made by compaction at CFU, there is little incentive to switch to bulk blending. This situation may be different if a new plant with large capacity and less ability to produce a large number of formulations was required.

Nevertheless, CFU will continue to evaluate bulk-blending processes in order to be ready if this technology must be used for specific applications. These investigations are directed mostly towards determining the availability of new materials with improved particle quality.

Recommendations for Installation of a New Fertilizer Compaction/Granulation Plant
As requested by the organizers of this seminar, I will close with some remarks which may be important for the installation of a new compaction plant.

1. All items presented and discussed above are valid.
2. The quality as well as possible variations in the quality of the raw materials to be compacted must be known. If no experience exists and/or the compactibility and product quality are unknown, extensive tests are recommended. Because of the influence of quantity and temperature of the recycle on compaction and product yield, a continuous operation, even during the testing phase, is preferable. The temperature of the raw materials must also be considered (winter/summer).
3. It is important to note that compaction/granulation requires extensive practical know-how.

4. Depending on the type of raw materials and climatic conditions, the hygroscopicity of certain fertilizers becomes an important issue in regard to:

- Storage and compaction of the raw materials
- Storage of the product
- Corrosion problems in the plant.

5. For various reasons a plant may have to be built that is less than ideal. Then, the following considerations should prevail:

- It is better to install less, but good equipment and facilities
- Expansion possibilities should be included in the initial design.

In 1971, CFU started with a relatively simple plant. Since then, various improvements were made with considerable expenditures. Today, still further expansion plans are envisaged. Why did this work not take place earlier? Experience and/or money were not available!

Today, after 18 years, the heart of the plant, the KÖPPER N roll press, is still in good condition and operating well. Only the wear parts had to be exchanged. Every year a planned maintenance period of 4 weeks takes place. As necessary, representatives of the manufacturers participate. It is most important to keep the plant in good repair to guarantee the availability of the plant during the peak season for fertilizer production and sales. During that period of time, the plant must operate for 4 months in a 3-shift-per-day, 6-day-per-week mode. Any disruptions of operation are most unwelcome.

6. An important consideration for the continuity of plant operation is the procurement and availability of spare parts. To guarantee timely service, a good relationship with the suppliers of the equipment is mandatory. It is prudent to also determine in advance potential remedies which would be available if a major breakdown should occur.

7. The extent of automation may vary within wide limits. Which level should be used, depends on the availability of funds but also on the number as well as background and training of personnel available for operation and maintenance. For example, it can be assumed that the manpower situation in Guatemala is quite different from that in Switzerland. The lack of personnel in Switzerland

requires, for instance, that the same man must have the technical knowledge needed to operate a relatively complex plant and, in case of difficulties, be willing to do heavy and dirty manual work.

In a highly automated plant it is also necessary to have trained technicians available for the maintenance of electronic equipment and to secure quick and reliable service from the manufacturer.

8. In conclusion, I would like to briefly tell you how CFU went about evaluating compaction 20 years ago. As you have seen, it is most important to put planning and construction of a fertilizer compaction/granulation plant into the hands of an experienced company.

CFU started the evaluation by carrying out tests with different fertilizer raw materials in the laboratory of KÖPPER N in West Germany. After more or less successful trials a small, simple pilot plant was installed at the CFU site to produce several tonnes of compacted, granular fertilizer for storage tests. Only after an extensive evaluation of the questions regarding product quality and the projected performance of the system was the production plant built. Since then, all maintenance and improvements have been carried out in close cooperation with KÖPPER N. The knowledge that, after 18 years, the same roll press is still in good operating condition and working well would have been a great comfort to us 20 years ago.

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