

ISMA* Technical Conference

Orlando, Florida, USA

23-27 October 1978

**In 1982, the name of the International Superphosphate Manufacturers' Associations (ISMA) was changed to International Fertilizer Industry Association (IFA).*

A ROUTE SAVING RAW MATERIALS AND ENERGY MAKES P2O5 AVAILABLE THROUGH WET PHOSPHORIC ACID PROCESS.

A. DAVISTER, Société de Prayon, Belgium.
S.V. HOUGHTALING, Davy Powergas Inc., Lakeland, Florida.

INTRODUCTION.

The events the phosphate fertilizers industry throughout the world has experienced during the last few years have puzzled many of us.

Indeed, the sharp rock price increases started at the beginning of 1974 have put out of balance many a fertilizers producer and created total disturbance in the import/export business of phosphate rock and phosphatic fertilizers products.

In conjunction with these facts came the more and more widely spread feeling that the usual sources of standard quality rock were quickly depleting.

Moreover, deliberate restrictions of phosphatic fertilizers use by the farmers for two or three consecutive years could create the impression that crops could do away with much less P2O5 than what they were usually given.

In this grim atmosphere, phosphatic fertilizers producers had to reconsider their short and medium range strategy and some were wondering about the future of their industry.

Today, blue patches are appearing between the clouds in our sky :

- the price of phosphate rock has been stabilized at what seems to be its equilibrium level,
- the farmers have resumed a more usual consumption of products,
- the developing countries are expected to sharply increase their demand in compound fertilizers.

International organizations have calculated that, in order to feed the growing number of inhabitants in our planet, fertilizers will have to bring to the soil 75 million tonnes P2O5 per year by the end of the century.

Inaccurate as it may be, this figure however shows that producers must get ready to satisfy a fast growing demand in phosphatic fertilizers, the current consumption being three times less.

This means that suitable solutions will have to be found to several problems but the challenge we will have to face now seems more exciting than the depressing problems we encountered in the recent years.

I. THE CHALLENGE OF THE NEXT DECADES.

Three main tasks are in front of us to meet this challenge :

1. to find the needed raw materials, in particular phosphate rock,
2. to transform these raw materials into finished products in the most economical way,
3. to find sources of finance to be able to settle down to the first two tasks.

As an engineer, I do not consider myself sufficiently competent and well informed to discuss the third point. Therefore, I shall leave it to the good care of economic and finance experts. I should like, however, to contribute some ideas to help in finding ways of solving the first two problems so that the third one would become less difficult.

PROBLEM NO. 1 : TO FIND RAW MATERIALS.

This should not be the biggest problem since the crust of our planet seems to be generously provided with deposits of calcium phosphates of various grades and qualities. We have however, naturally already started using the most accessible deposits and in using these we have, if I may say so, cut away the best slices of material. Moreover, there seems to be very little chance of discovering new phosphate rock deposits in the developed countries, since such countries have already been intensively prospected and it would be very lucky to find new deposits where the most important needs will arise.

Additional phosphate resources can be found :

- 1) by extending existing mines towards neighbouring areas where lower quality deposits have been located,
- 2) by mining known deposits considered, until now, economically unworkable,
- 3) by the discovery of new deposits which could exist either at unusually low depth or in remote and less readily accessible areas.

PROBLEM NO. 2 : TO TRANSFORM ECONOMICALLY THE RAW MATERIAL INTO FINISHED PRODUCTS AND MAKE THEM AVAILABLE TO THE FARMERS AT THE LOWEST COST.

Needless to say that this is a very complex question that requires a lot of thinking.

The goals are easy to determine : to use as little as possible raw materials and energy in making the fertilizer products available to the farmers.

The decisions to be taken are :

- which products should be made
- where to locate the production units
- how to make the products.

At this stage, I should like to submit to you my philosophy about fertilizers production and distribution.

The needs :

It is obvious that the increasing requirement of fertilizers will not be equally distributed throughout the world. Increases in usage will be rather slow in developed countries in which fertilizers are already in extensive use, but on the other hand, developing countries are bound to increase their use of fertilizers per capita or per unit of cultivated surface.

As a consequence, it is very unlikely that fertilizer production will greatly increase in developed countries which have no phosphate deposits. The production in these countries will only grow to meet regional demand.

To satisfy the needs in fertilizers, in every part of the world, there will be continuous and growing movements of large quantities of material of three kinds : - phosphate rocks,
- intermediary fertilizer products,
- finished fertilizer products, ready for use.

The sources :

The choice of material preferred for mass export/import is, of course, a matter of economical and financial decision to be made case by case but it seems unlikely that the enormous demand of fertilizers will be met by the import of finished products, such practice will probably be used only in rare cases, for example, when trying to penetrate a new market.

On the contrary, phosphate rock imports will continue to be necessary and will develop up to a certain point ; however, export of high quality rocks will mean deeper and deeper beneficiation of an ever decreasing rock quality, thus leading to unnecessary waste of energy and of P₂O₅. On the other hand, using low grade rocks for export will also have major disadvantages since the transport costs incurred in moving the lower grade will inevitably become progressively higher.

The alternative solutions :

a. On or near phosphate rock deposits, the use of low grade material can be contemplated for the manufacture of intermediates. In this case, the processing of the ore may be regarded as a chemical beneficiation. The intermediate thus made may then be exported to several markets. The advantage of exporting intermediates instead of a specific finished product lies in the fact that the intermediates together with other complementary materials, can be mixed to give a variety of fertilizer ratios suited to the local end user requirement. Several types of mixing may be used for this purpose :

- complete mixing, with or without granulation,
- dry mixing e.g. bulk blending,
- mixing of clear liquid or suspension fertilizers.

b. Considering the enormous quantities of P2O5 involved and the long distances to be covered, one can hardly contemplate that the needs may be covered by resorting largely to low concentration fertilizers. Therefore as the areas where phosphate deposits are located do not necessarily coincide with the areas where ammonia or nitric acid can be economically produced, it is highly probable that the transformation of phosphate rock into phosphoric acid will be a necessary step in many of the new fertilizers production circuits. Phosphoric acid technology developments will therefore be essential in the overall economy of new fertilizer production lines. This technology will have to be adapted to the new situations we are already starting to face.

II. CHANGING CONTEXT OF A PHOSPHORIC ACID PLANT.

Like other processes, upstream as well as downstream in the chain, the phosphoric acid processes will have to show some flexibility in the specification of raw materials as in the quality of products in order to fit in the complex. This flexibility does not mean that the design of phosphoric acid plants should be made in such a way that any phosphoric acid plant can give any product by processing any raw material. It only means that, in a particular and well defined case, equipment must be provided and/or provision must be made for the treatment of a rock, the quality of which can vary from time to time, bearing in mind that the phosphoric acid produced has to be used further on.

Let us consider for a while the changes that are already emerging upstream and downstream from the plant and how we see the adaptation to these changes.

A. Changes downstream.

It may seem strange to start with this point but one has to consider that changes downstream will inevitably condition the changes a phosphoric acid plant can tolerate upstream. These downstream changes may be of two types :

- 1) A change in the quality of the phosphoric acid produced that would be acceptable to the fertilizer manufacturer. When phosphate rocks of a lower grade are used, more impurities are found in the product acid. Some of these impurities can be tolerated in the fertilizers as they have little or no influence on either the manufacture or on the quality of the products.

On the other hand, many impurities do have an effect either on the running conditions of a fertilizer plant or on the quality of its products and some impurities affect both.

Technological adaptations in the fertilizers plant itself will probably overcome some operational problems caused by part of these impurities but for some others, the fertilizers manufacturer will only accept them provided they are tolerated in the finished products. For example the acceptance of a decrease in the water soluble P₂O₅ will necessitate a marked change in attitude by fertilizers users in many countries of the world. Besides, as I said earlier, there will be economical limits for the transport of lower grade fertilizers, even when their use will be accepted by the farmers.

So, one has to anticipate that, for a number of years to come and in many cases when a classical quality phosphoric acid will be needed, the amount of impurities in the phosphate ore will have to be limited or else, and this is the second type of change that can happen downstream the phosphoric acid plant, a clean up of the product acid will have to be considered.

- 2) Today, post-treatment techniques are available for only a few impurities but several others have been studied in the laboratory. The development of these post-treatment techniques is yet of an unknown value. Solvent extraction methods are, of course, of rather common use nowadays but the costs of such methods are only justified if one uses the product acid for other applications than the manufacture of commonplace fertilizers. On top of that, solvent-extraction processes eventually produce a residual phosphoric acid even more heavily laden with impurities than the usual grade of phosphoric acid, creating, in turn, a new disposal problem.

It is obvious that any breakthrough in the post-treatment techniques would be an event of major importance in the field of phosphoric acid manufacture. It would allow the phosphoric acid plant to accept a much lower grade of raw material for producing a very impure phosphoric acid. It is almost certain however that such processes, if discovered, would have their drawbacks such as the production of a residual acid containing solids together with more impurities or the need for a certain amount of costly additives. It is the irony of our situation that to eliminate some impurities from a product, we very often have to start by adding new impurities to that product.

The above considerations show that little evolution is to be expected in the near future in the chain of fertilizer manufacture and usage downstream from the phosphoric acid plant. Needless to say, however, I would be very glad to hear other views.

B. Possible changes upstream from the phosphoric acid plant.

Evolution of this aspect will mainly concern the quality of the phosphate rocks used as raw material.

Until now, the economy of making phosphoric acid and the economy of beneficiating phosphate rock for that use have always dissociated (and considered individually).

Indeed, on the one hand, the miners were trying to produce a best possible quality of phosphate rock, for whatever usage ; on the other hand, the chemical producers were using this well beneficiated rock to often produce a merchant grade phosphoric acid even if its further usage was the manufacture of compound fertilizers.

The recovery of each operation was considered satisfactory but the overall P₂O₅ recovery of both operations was in range 55 to 75 % at best.

If we consider both operations as having one and unique goal, i.e. making P₂O₅ available at the lowest cost and using as little as possible energy and natural resources, we have to concede that in many cases, phosphoric acid (may be of a lower quality) could be made from a less beneficiated rock so that the P₂O₅ recovery of the beneficiation operation itself could be boosted up, making the overall recovery reach the 75 to 85 % range.

Already, in recent years, we have had to use rocks of declining grade as the result of an increase in silica content in the rock, an impurity that did not influence greatly the conditions of plant operation nor the quality of the produced phosphoric acid. Silica is an inert ballast that is mostly removed as a solid with the by-product gypsum. The quality of the product is thus quite unaffected. Unfortunately, silica is really an exception among impurities : it does not even increase the sulphuric acid consumption in the phosphoric acid manufacture and because of its properties, silica was not a challenge to phosphoric acid technology and hence did not cause any progress in the field. Other impurities make more demands on the technology and will continue so increasingly in the future. One of these impurities will be discussed in the next chapter.

III. THE ROLE OF PHOSPHORIC ACID TECHNOLOGY.

A. Previous adaptations of the phosphoric acid technology.

My company which has been engaged in the fertilizers field for 40 years and in phosphoric acid process engineering for 25 years has had to constantly move forward, like other companies. Several generations of phosphoric acid plants may be distinguished :

1. The first one in the fifties. Its main characteristics were :

- round steel attack tanks each divided into four compartments,
- dilution and cooling of sulphuric acid with lead tubes,
- filter of up to 40 m² active area,
- few automatic controls.

The size of these plants ranged from 25 to 200 tonnes P₂O₅/day.

Although it was the first series of plants built according to our process, they did pretty well and some of them are still running after more than 20 years, to the satisfaction of their operators.

2. The second generation of plants came in the sixties. In these, the attack tank was now a concrete monobloc. The dilution-cooler for sulphuric acid was still in use but it was of a more modern type : the carbon tubes heat exchanger.

The capacity of these second generation plants reached about 900 tonnes P₂O₅/day. The filters used were developed to reach an active area of about 160 m².

3. The third generation of plants was introduced in the early seventies. The concrete attack tanks had proved to be very satisfactory and have been retained, but the circulation pattern inside the attack tank has been changed significantly to be independant of the flow of slurry required for the operation of the flash cooler.

In addition, agitation in the attack tanks is modified in order to obtain improved homogenization of the slurry and this in turn, allows the use of straight, concentrated sulphuric acid. The water previously used for the dilution of sulphuric acid may now be used :

a) On the filter for a more efficient wash of the gypsum cake (even using 2 counter-current washes instead of 3) ; moreover for this use, lower quality water may be used instead of the clean water previously required for the sulphuric acid dilution. This change brought an important modification in the dirty water balance of a phosphoric acid plant.

b) With the phosphate rock whenever wet rock grinding and handling is desired.

B. Conditions and tools of progress.

This evolution in the process was possible thanks to the combined action of two main factors : firstly,

- the feedback of information gathered throughout the world during plants startups with many different types of phosphate rocks ; secondly,
- the pilot plant tests that were carried out with a great number of phosphate rocks coming from various mines. Both sources of information will continue to give us a firm basis for the further adaptation of our technology.

In particular, our testing facilities have been used recently to study the behaviour of a quite typical low grade rock, whose name I may not mention as the work was done at the request of a foreign company. This rock contains soluble as well as insoluble diluent components and these have their effect :

- a) On the formation and composition of the precipitated solids which make up the cake to be filtered and,
- b) on the characteristics of the liquid phase and consequently, of the acid produced.

Although, the study is still underway, the results obtained so far seem to indicate that our dihydrate process, slightly adapted to this case, could be suitable for the industrial use of that rock. The economics of this may be justified when considering all the cost factors, from the extraction of the rock to the production of intermediate and finished fertilizer products and taking into account the energy balance, the overall P₂O₅ recovery and the local market conditions. Throughout this study, reference has been made to industrial experience acquired, mainly with other low grade rocks and to results obtained during previous laboratory tests on low grade rocks. For example, the filtration of solids has profited by the adaptation of the Prayon filter for filtering fines slurries in the non-ferrous metals hydro-metallurgy.

To meet the new requirements the technique we have used is based on the filtration and washing of thin cakes. To optimize this operation, our filter has been adapted so that the filtering pans are kept in a perfectly horizontal plane. By this means the optimum washing is obtained by successive displacement and filtration cycles which are still acceptable are attained with a cake exhaustion similar to that presently obtained from the better rocks.

On the other hand and for the time being, we believe that it is necessary to make allowances for the nature of low grade rock and be satisfied with producing a filter acid of an acceptable P₂O₅ content provided it is compatible with the amount of steam available from the sulphuric acid plant, for its evaporation. In that respect, it should be noted that the soluble diluent components present may lead to limit the strength of the concentrated acid.

By using these techniques, the water balance in the process is such that it allows to have available for filtration and washing a larger than usual amount of water which, when judiciously distributed, compensates for the reduction in filterability of the cake.

Clearly a major study has been necessary for each of the parameters of the treatment process, for example, the sulphuric acid attack of the rock and the formation of a slurry suitable for the filter. Each of the parameters was first studied separately, then combinations of several of them had their effects studied on the whole process.

In this way we have established that it is possible to ensure good P2O5 extraction of the low grade rock when reaction conditions in the attack vessel are suitably adjusted. The physical and chemical conditions of the attack section in the reaction tanks must of course be highly uniform and well controlled, so that one remains in the dihydrate precipitation area.

After studying and testing this rock, we expect to do likewise with other rocks which are, until now, deemed difficult to treat in phosphoric acid manufacture and which may be either of the same type or present other characteristics depending upon their origin and constitution. We hope to be able to determine to what extent the results of the treatment can be economically justified according to the importance of the adaptations to the dihydrate process. It will of course be necessary to use larger filtration surfaces than in the past, more particularly, larger than those generally in use with reputedly good rocks.

In a new large plant in South Africa, Prayon has, for the first time demonstrated on an industrial scale the running of a single attack tank followed by two Prayon filters. The four one thousand metric tonnes of P2O5 per day units for USSR, which are currently under construction will also each be fitted out with two filters.

When using low grade phosphate, the increase in investment for large filtration surfaces is expected to be mostly justified within the total cost of a project situated on or near a mining site by considering

- a) the cost price of a tonne of P2O5 in a low grade rock which does not have to be transported and
- b) the overall yield of P2O5, from the matrix to the fertilizer.

C. Typical application : magnesium in phosphate rock.

It is well known that the deeper a sedimentary phosphate rock deposit becomes, the more its calcite matrix changes to a dolomitic one, raising the $\frac{\text{MgO}}{\text{P2O5}}$ ratio.

Generally, magnesium has been considered objectionable at $\frac{\text{MgO}}{\text{P2O5}}$ ratios above 1.5 % because this makes the gypsum filtration more difficult and gives a precipitation of water insoluble ammonium magnesium phosphate upon neutralization of the phosphoric acid by ammonia.

Now the beneficiation can hardly improve the $\frac{\text{MgO}}{\text{P2O5}}$ ratio of a given phosphate rock ; as a rule of thumb, one considers that to cut this ratio by half, you have to loose 50 % of the P2O5 in the steriles.

So, there is incentive to use high magnesium rock as long as economics or resource conservation is considered.

Testing rocks with higher $\frac{\text{MgO}}{\text{P2O5}}$ ratios, we have found that it is quite possible to make wet process phosphoric acid from a phosphate rock whose $\frac{\text{MgO}}{\text{P2O5}}$ ratio is higher than 10 %. Of course, to reach this, we have put to work most of the means mentioned hereabove; notably we have eased the filtration as much as possible by filtering relatively weak and hot acid through rather thin cakes.

As the acid is produced, what shall we do with it ?

Of course, it is possible to bring its $\frac{\text{MgO}}{\text{P2O5}}$ ratio down by chemical or solvent extraction purification ; but this costly operation is only justified if the acid is used to produce pure technical or feed grade phosphate or to neutralize by ammonia as a clear liquid fertilizer and very often it will be cheaper to use low magnesium rocks to these ends.

On the other hand, if the objective is to produce solid fertilizers, there is really no need to eliminate the magnesium and, on the contrary, this seems quite an agronomical nonsense.

Indeed, it may be useful to remember that :

- a) Magnesium, though not recognized as a fertilizer element like N, P or K is accepted as a major element of the plants as well as Ca and S.
- b) The presence of magnesium in sufficient amount helps the assimilation of phosphorus by the plants (Ref. 1).

This has been recognized by our ancestors and as soon as the technology was available ammonium magnesium phosphate has been produced in Western Europe between 1920 and 1940 (Ref. 2 and 3).

The trend towards more and more concentrated complex fertilizers during the last thirty years has partially offset the role of magnesium and consequently we notice more and more often that it is now necessary to bring additions of magnesium to the soils.

So it seems only logical to keep Mg with P when nature supplies them together and to develop the processing that will enable the production of a fertilizer whose P2O5 will be partly present as ammonium magnesium phosphate.

Please note that the latter, although not water soluble, is available and perfectly assimilated by the plants. One may even say that, contrary to the water soluble P₂O₅ that may be insolubilized by the soil metallic cations, the P₂O₅ of the ammonium magnesium phosphate is not liable to that insolubilization and remains available for the plants.

References.

1. Phosphore et Agriculture (I.S.M.A. publication) N° 71, October 1977.
2. Available Magnesium in Mixed Fertilizers, by Allan F. Burns and Arthur M. Smith, Ag. Chem., September 1966.
3. Archives of Société de Prayon, Belgium.
 - Official letter, dated September 13, 1933, concerning magnesium-ammonium phosphate production.
 - Phosphate Ammoniac-Magnésien - Pamphlet edited by "Société Anonyme La Nouvelle Montagne", Engis, Belgium - January 1932.

IV. WET ROCK GRINDING AND FEEDING.

A clear example shows how quickly the technology of phosphoric acid is able to adapt itself to new concepts when it is proven that it constitutes a major step forward for our industry. I am referring to the very interesting technique of wet grinding and wet feeding of phosphate rock to the reaction system.

Wet rock grinding of phosphate rock has progressed from conception to a commercial process over the past five years. Phosphoric acid producers no longer ask the question "Will it work?", but rather "Will it save us any money if we change from dry to wet grinding?" Let us briefly review the wet grinding process before examining the advantages and disadvantages of changing the rock grinding process.

Wet phosphate rock as it comes from the beneficiation plant is usually 8 % to 12 % moisture. Rock is fed from a storage bin or silo onto a feed conveyor where it is weighed continuously. Process water is rationed to the mill based on the amount of rock feed. The rock and water are mixed at the mill inlet into a slurry about 68 % solids and 32 % water. The wet grinding unit is usually a ball mill, although rod mills can also be used.

Slurry is taken out through a trommel screen attached to the mill. Slurry falls into a small pump tank and is immediately pumped away to a surge tank of 3 to 4 hour capacity. Rubber lined horizontal pumps are the usual choice for moving the slurry. Sixty-eight percent slurry is pumped and metered from the surge tank to the attack tank for the reaction with 93 % sulfuric acid.

A variation of this process is to install one or more mechanical screens between the slurry pumps and the surge tank. This separates out the oversize (usually 15 % of the slurry) which is returned to the mill inlet by gravity. The product or "on-size" is sent to the slurry surge tank.

In the last five years, new plants for wet rock grinding have been designed and constructed for companies such as Agrico, C.F. Industries, and W.R. Grace. Several companies have converted their dry mills on old plants to wet grinding. Agrico, Grace and Freeport are three companies that have changed and are back in production. Several other companies are making plans to change in the near future.

The plant converted at W.R. Grace was a typical 12-year-old Prayon plant making phosphoric acid using dry grinding. The unit has been debottlenecked several times, so it is producing well over its design of 550 STPD (500 MTPH) of P2O5. Finally, the drying system became the major bottleneck in the process.

Phosphate rock is a world commodity and is tied to world trade conditions. It is also tied to the world cost of energy. For example, the fuel cost that is involved in dry grinding has gone up from \$ 0.50 per ton of rock to \$ 1.50 in recent years (Florida prices). It is expected to go higher as the price of fuel oil or natural gas increases. The cost of electricity which is about \$ 0.75 per ton of rock is also tied to the cost of energy. If both of these costs inflate at the rate of 8 to 10 % per year, the price of dried phosphate rock will be priced out of the market. Wet, dewatered rock (8 to 12 % moisture) will take its place.

At present conditions, some producers of rock and phosphoric acid realize they can save money by converting to wet rock grinding. The acid producer that has no mine and is buying his rock under contract or on the open market knows that his costs have gone up. He does not know for sure if wet rock grinding will help him or may-be give him a new set of problems. He needs a complete evaluation.

He has possibly three alternatives and they could be :

1. Status quo under a long-term contract (possibly with some cost escalation),
2. Transport wet rock and install rock dryer,
3. Convert to wet rock grinding.

Alternate (1) is the "do-nothing" attitude in hopes that the situation or problem will go away. The acid producers know that as time goes by their profit margins will shrink. Their raw material costs will certainly rise with the cost of energy and transportation.

Alternate (2) may be the best route for some producers to lower raw material costs. If cheap fuel or low cost energy is available at the plant site, a dryer installation is a distinct possibility.

Alternate (3) involves a "revamp job" or revision using the same mill or possibly a new mill.

At W.R. Grace, the conversion of the rock grinding unit from dry to wet took about six weeks. This means that production will be zero for this time period unless another unit is operating. There will also be a period at variable rate in order to solve or eliminate any start-up problems.

Recovery of P2O5 remains the same. At W.R. Grace, the recovery of P2O5 based on losses in the gypsum cake were about 95 % before shutdown. After converting to wet grinding, the recovery settled out about 95 %. There is essentially no noticeable difference in recovery.

The new technology on wet rock grinding is spreading throughout the world. The process is now recognized in the industry as proven and technically sound. It is recommended on new installations. From studies made throughout the world, we can see no major problems on the use of wet rock grinding except the possible exception of high chloride rock.

1. Extra weight per unit of P2O5 will have to be transported with the rock. Approximately 10 % extra weight will have to be transported and handled. On long distance transportation, this amounts to \$ 1.00 - \$ 1.50 per ton of rock.
2. Severe climates cause handling problems. In cold climates, the rock will freeze in transport and in outside storage. Inside storage is usually an expensive proposition.
3. Ball wear in the mill is usually higher. Figures on ball wear coming from the new plants place ball wear at 0.5 - 0.6 pounds of balls per ton of rock while dry grinding is 0.1 - 0.2 rate.
4. Loss of production during change over. It takes 4 to 8 weeks to convert an existing ball mill. Loss of production and shutdown of the sulfuric acid plant are two factors that must be considered.
5. Rock source and quality is another major consideration. The new mines opening in the world in the next few years will definitely have to be investigated as a cheaper source of rock.

One point we have not covered so far is what changes must be made to attack and filtration areas to adapt to this process. The major changes are :

1. Dilution cooler is eliminated because water is used with the rock.
2. Flash cooler heat load is increased since all heat (dilution and reaction) is now removed by flashing vapor.
3. Strong sulfuric acid (93 or 98 %) is used directly in attack tank.
4. Recycle acid is used as a diluent for sulfuric acid in special mixing tees.
5. Increased vapor and fluorine emission is probable and fume ducts and scrubber should be modified to handle increased load.
6. Wet rock is introduced into dip tubes below the slurry surface in the attack tank.

Filter operation remains essentially unchanged since the reaction slurry, filter feed and filter wash water remain unchanged.

Defoamer usage is not significantly affected by wet or dry grinding. Defoamer usage is generally tied to the types of rock being used.

Recovery of P2O5 is not increased or decreased by wet rock grinding. As mentioned before, the W.R. Grace plant was operating at 95 % P2O5 recovery before the revamp and now it is showing 95 % P2O5 recovery after the modification.

V. CONCLUSIONS.

In order to satisfy the growing demand of phosphatic fertilizers, we shall have to rely on new and, certainly quite often, lower grade phosphate rock.

This will imply that :

- on the one hand, we develop technology to process these rocks without leaving a high percentage of their P2O5 content in the portion currently discarded as sterile,
- on the other hand, we persuade agronomists not to require unnecessary fertilizer qualities such as the water solubility of the P2O5 when it is not proven essential.

As Dr. Charles Wilson of Collingwood Grain said earlier this year in an article published by Fertilizer Solution : "... it is up to ... fertilizers dealers to see that the farmer buys what he needs - not necessarily what he wants !".

We must, from now on, have a broader vision of our industry, a vision without prejudice, a vision that makes us clearly determine, in each case, what are the final products to be made and which is the most sensible and economical way to make them.

This new vision may lead us to consider, in some cases, that phosphoric acid manufacture has to be regarded merely as a chemical beneficiation of the phosphate rock, not necessarily producing a merchant grade acid, but merely making P2O5 available for further processing.