



FLORIDA PHOSPHATE TECHNOLOGY 2000

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The Florida phosphate industry faces a long term challenge from foreign competition, resulting in pressure to minimize operating cost. Will the Florida industry knock along and watch an ever-increasing share of export markets be eroded by foreign competition? Or will the industry modernize, trim costs and prosper?

The answer depends to a large extent on how effectively the industry can implement cost saving innovations and processes into existing plants. The next few years will not be a time for building new plants in Florida, because a sluggish market is likely to discourage growth. This will be a time for challenging traditional methods and for developing innovative solutions to problems. We'll need to be quick to react to changing situations and to implement new technology. Conventional answers to some basic issues will have to be questioned all over again, and some sacred cows will have to get kicked.

After all, that is how many of the advances of the past were achieved. I'll cite some examples of past break-throughs to illustrate how this happens.

I'll also make some predictions about what might happen in the Florida phosphate industry between now and the year 2000. It might prove amusing to re-read this article in a decade.

ROCK GRINDING

Lets start with grinding of phosphate rock, which is the first thing that happens process-wise to phosphate in a phosphate chemical complex. Many years ago everybody ground the rock dry. If someone were to ask why not wet grind rock for a phosphoric acid plant to save all that drying cost, there would be an abundance of answers for why not, such as:

It would put in more water than the phosphoric acid plant could tolerate.

Ground rock slurry can't be de-watered.

You would not be able to measure the rock feed.

It would mess up the pond water balance.

Wet rock slurry would be impractical to handle and transfer.

Answers like these often become sacred cows that discourage progress, especially since they aren't qualified by important "if" statements that really define the limitation, like "if you continue to dilute the sulfuric acid feed", "if you don't reduce filter wash water", "if you don't increase flash cooling capacity", and "if you can't improve on conventional equipment."

All of these answers had an element of truth, yet at least four out of the five have been proven false, as is plainly demonstrated by the fact that most Central Florida phosphoric acid plant have been wet grinding rock for many years. It is done despite not being able to de-water the ground rock slurry - at least not in a practical manner with Central Florida rock. As far as I know, that sacred cow is still alive and well.

While we're on the topic of rock grinding, how about a few outrageous questions about current practice:

Why grind the rock?

Why grind it so fine (minus 35 mesh)? Especially when there is at least one phos acid process (Hydro Hemi) than can handle up to 10 mesh size?

Why not try again to de-water it if you only have to grind it to minus 10 mesh?

Before long most Central Florida rock will be concentrate that is smaller than 20 mesh, and eventually smaller than 35 mesh. Why grind that?

CO-GENERATION

There was a time when no Florida phosphate producer generated electricity from the surplus heat from the sulfuric acid plants. The reasons were:

There was usually little or no surplus heat.

Sulfuric acid plants were not efficient enough to produce much surplus heat.

Even if they did, electricity was so cheap that it was uneconomical to modify the sulfuric acid plant and generate electricity.

There was little appreciation of the environmental benefits of co-generating power from waste heat.

Times have changed. Energy is more valuable. Sulfuric acid plants are much more energy efficient, so they make a lot of surplus steam, and less steam is used where it is not economical - like for vaporizing ammonia and for flash cooler vacuum ejectors. Most phosphate plants co-generate electricity to use, and some sell surplus electricity to electric companies.

Unfortunately, the co-generation of surplus electricity for sale is stifled by political problems which result in inability of most co-generators to receive a fair price for exported electricity. This situation hurts not only the co-generators, but also the public, who would benefit from the advantages of electricity production with no environmental damage and no consumption of fuel.

A decade ago concern for energy conservation almost brought a revolution in co-generation. The Federal PURPA regulations stated that co-generators should be paid a good price for electricity which they export to utility companies. However, utility companies defeated this effort.

Now the incentive for co-generating electricity is coming from concern for the environment. Power production from fossil fuels results in acid rain and fly ash emissions, contributes to the greenhouse effect, and incurs a solid waste disposal problem with ash and spent scrubber sludge. Nuclear power operation is normally clean, but there is a serious radioactive waste disposal problem and concern about a catastrophic accident. Co-generation of power from waste heat solves all of these environmental and energy resource problems, to the extent that it can be implemented. Since it uses waste heat which would otherwise be lost, there is virtually no consumption of fuel. Also, there is practically no environmental impact from co-generation.

Congratulations are in order for IMC Fertilizers. They have recently negotiated a decent price for exported electricity. May others follow their lead!

PHOSPHORIC ACID

There was a time when every phosphoric acid plant had a series of reactor tanks, interconnected by launders. Then Prayon, Dorr-Oliver, Swenson, and others developed single-tank reactors. Some continued to use discrete zones within the reactor, and some did not. Further improvements to processes have increased capacities, recoveries, and on-stream factors.

Better hardware and better materials of constructions have resulted in higher recirculation rates, more efficient agitation, and reduced maintenance and cleaning costs. Filtration improved greatly with the introduction of improved tilting pan and belt filters.

Phosphoric acid evaporators were thermal-siphoning type, because forced circulation pumps were impractical. Now they are all forced circulation. A variety of other improvements have been added to some or all phosphoric acid evaporators, including high efficiency entrainment separators, expanded-area lump screens, more compact design, and better circulating pumps and heaters.

All of these improvements involved questioning traditional methods and the resourcefulness to develop improved methods.

Now for a few questions for today's traditional methods:

Why make weak phosphosphoric acid at 26-28% P2O5 concentration and then spend a fortune to concentrate it enough to make any use of it?

Why spend more for that trickle of defoamer than you do for all of the operating crew?

Why not do something like this?

Start with damp, unground concentrate.

Convert the phosphoric acid plant to a hemihydrate (or hemi-di) process which can handle the concentrate without grinding.

Make 40% P2O5 filter product.

Feed the 40% P2O5 filter product directly to the existing DAP plant. (There's more later about single-strength DAP feed acid.)

Eliminate evaporators.

Co-generate a bunch of electricity from all of the steam that is saved by not running the evaporators.

Find a way to get a decent price for all of the surplus electricity that will be exported.

DAP

Today's DAP (diammonium phosphate) plants are greatly refined from the original TVA process, which was developed over a quarter of a century ago. The original process would not be competitive in today's market - a situation which holds true for many processes of that age after a lot of clever improvements have been added.

Today's DAP plants make more capacity - both in terms of total production and capacity per unit of equipment size. They can run with a lower recycle ratio and less fuel and utilities per ton of product, and they are easier to operate. Many plants vaporize ammonia with waste heat rather than valuable steam, and many have added improvements such as two stage acid scrubbing, advanced design pre-neutralizers, granulators, screens, recycle systems, and scrubbers. Product cooling is sometimes enhanced by an ammonia chiller, which puts cold air to the product cooler while vaporizing some of the ammonia feed.

One area which hasn't improved much is required acid feed strength. I know a competent engineer who did a heat and material balance before he knew much about DAP plants. He wondered why the average feed acid concentration was typically 39% P₂O₅, instead of his calculated 30%. He had shrugged off wasted heat, but he made a good point. A lot of heat gets wasted in a modern DAP plant.

Why do Florida DAP plants use a combination of weak and strong phosphoric acid feed - typically 28% and 54% - rather than a single acid of equivalent strength - about 39%? The answer is because they couldn't meet air pollution regulations due to increased fluorine evolution. Is this still true? Consider improvements which have been successfully implemented into some DAP plants, which result in improved scrubbing performance:

Two stage acid scrubbing - better efficiency thru counter-current scrubbing.

Belledune style ammonia vaporizers. These use some of the waste heat from the pre-neutralizer off-gas to vaporize the ammonia. The gas which goes on to the scrubbers is much cooler. Cooling improves scrubbing by reducing vapor pressure.

Advanced scrubber design.

Most DAP plants use expensive tailgas scrubbers to meet modern standards for low fluoride emissions from the stack. Have the aforementioned scrubbing improvements rendered tailgas scrubbers unnecessary for meeting this regulation?

These same scrubbing system improvements can reduce ammonia losses from the DAP process to consistently less than 1%. This

figure may appear in plant design claims, but without the advanced technology, ammonia losses of 3 to 7% are common in real life. This is especially true for plants that have been modified to operate at well above original capacities.

Why do Florida producers spend a lot of extra money to make DAP with 18-46-0 analysis, whereas they could make slightly lower analysis product for significantly lower cost? Florida phosphate producers spend a lot on extra clarification and evaporation to make phosphoric acid which is pure enough to make 18-46-0. I'm well aware of the marketing explanation for not accepting lower analysis DAP than 18-46-0, but I'll call it a sacred cow and challenge some body to kick it. I'm not advocating that anyone should go to market with low analysis DAP today, but I wonder how long it will be before there is more flexibility in DAP analysis. The same applies to TSP (triple superphosphate).

Another approach to the DAP analysis problem might be to use a phosphoric acid process which inherently makes a higher purity acid for the DAP plant. For example, one plant which converted to the Hydro Hemihydrate process for making phosphoric acid from Florida rock found that the product acid was so much purer that the DAP grade immediately jumped two points to 18-48-0, without evaporation or clarification. They had to make process changes to reduce the DAP grade to the specified 18-46-0.

PHOSPHATE ROCK QUALITY

The quality of phosphate ore that is mined in central Florida is deteriorating as more is mined and mining sites move further south. Rock grade will continue to decrease, and the level of troublesome impurities like iron, aluminum, magnesium, potassium, and carbonates will increase. Mining will become more expensive as the matrix layer generally gets deeper and thinner.

Deterioration of phosphate rock quality tends to cause increased consumption of sulfuric acid and defoamer, reduced filtration capacity, increased scaling of lines and equipment, various operating and maintenance difficulties, lower product purity and various product quality problems.

The portion of phosphate matrix which can be made into usable pebble size phosphate rock will decrease and perhaps disappear as most will have to be beneficiated to concentrate. The size of concentrate will gradually decrease to predominantly under 35 mesh.

Beneficiation plant performance will become increasingly crucial to the usability of the phosphate rock. Advanced beneficiation processes will become more important as matrix grade declines. People who are involved with mining and beneficiation will need to become more aware of what the chemical plants need in terms of phosphate rock quality.

Processes, equipment, and operating techniques for making phosphoric acid, DAP, TSP, MAP, etc. will need to become more tolerant of troublesome impurities. People who are involved with chemical processing will need to become more aware of changing phosphate rock quality and beneficiation possibilities.

I think that rapport between the beneficiation and chemical processing ends of the phosphate industry has been lacking. I accept part of the blame, since I am a chemical engineer who knows little about beneficiation. I once did a preliminary process design for a beneficiation plant (with a lot of help from a beneficiation expert) and found it to be fascinating. Beneficiation consists of a collection of unit operations, and these individual unit operations are the type of things that chemical engineers get into every day. So why don't you see chemical engineers around a beneficiation plant?

Many of the Central Florida AIChE members attended the joint Phosphate Conference in Lakeland last fall, which was co-sponsored by the AIME, AIChE, FIPR and AIPG. This conference featured presentations involving mining, beneficiation, chemical operations and environmental issues. This was a good opportunity for beneficiation and chemical people to become more acquainted with each others' situations. The local AIChE welcomes mining and beneficiation engineers to attend our meetings, and we're welcome at AIME meetings.

THE NEXT DECADE

The Florida phosphate industry in the 1990's is likely to see major changes in raw material, advancing technology, opportunities for innovation, and a stable market. Marketing forecasts for the next several years indicate slow growth for the Florida phosphate industry, but these times are expected to be fairly stable. Competition for the export market is expected to be increasingly difficult as Florida mining and beneficiation costs increase faster than foreign mining and beneficiation costs.

Such a climate will discourage the building of new plants, particularly since there remains some idle phosphate capacity in Florida. Modification of existing plants to minimize cost and maintain product quality will be essential. This trend has started already, as phosphate companies finally have capital to spend on a backlog of worthwhile process improvements.

R & D

Do you remember R&D? Most phosphate companies shut down R&D departments about twenty years ago. I'll predict an increase in process development work on main-line phosphate chemical operations by manufacturers and governmental organizations like the Florida Institute for Phosphate Research. Projects will relate to changing rock quality and modifications to existing plants to reduce operating cost.

ROCK QUALITY

Beneficiated phosphate rock will become mostly concentrate. Rock quality will become increasingly difficult to maintain in Central Florida. Part of the answer to the rock quality problem will be advanced beneficiation technology, and part of the answer will be process improvements in phosphoric acid production. If rock quality problems are not solved, the result will be reduced capacity of existing plants and fertilizer quality problems.

CO-GENERATION

Emphasis on the environment and energy conservation will bring increasing pressure on utility companies to pay a good price for co-generated electricity. The result could be incentive for phosphate chemical plants to convert more waste heat into power for export in addition to that for internal consumption.

HEMI PLANTS

The combination of fine rock with low moisture, a good price for exported electricity, and a need to minimize costs is likely to result in conversion of Florida phosphoric acid plants to hemi-

hydrate or hemi-di processes. Hemi processes can use concentrate as-is, thus saving the grinding cost which is required by conventional dihydrate processes. The low rock moisture of damp concentrate permits an acceptable process water balance, whereas conventional wet-ground rock prevents hemi operation, because it contains more water than a hemi process needs. An attractive export power value would provide major financial incentive, because steam which is presently used to concentrate phos acid would run turbo-generators. Additional incentive would come from improved product purity and - in the case of hemi-di - from increased recovery.

ABOUT THE AUTHOR

John Wing received a Bachelor of Chemical Engineering degree with Honors from Univ. of Florida in '61 and a Master of Engineering in Administration from Univ. of South Florida.

His experience includes 25 years in phosphates, with positions in process design, project management, consulting, technical service, process development and production. He is a registered Professional Engineer and a Fellow of AIChE.

Major phosphate experience includes modification and expansion of several phosphoric acid plants, design of five existing phos acid evaporators, a fluosilicic acid recovery system, expansions of DAP and GTSP plants, and design of over 20 existing scrubbers.

He was responsible for process design for a very successful conversion of a Prayon dihydrate phosphoric acid plant to Hemihydrate operation at Belledune, Canada.

He is now Vice President of the engineering and consulting firm HiTech Solutions Inc.