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ADVANCED AMMONIA PHOSPHATE SCRUBBING WITH MINIMUM WATER DISCHARGE

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RESUME

HiTech Solutions, Inc. de Lakeland, Floride (Etats-Unis) a récemment mis au point un système à partir de plusieurs techniques existantes de lavage d'engrais. Ce système est installé et fonctionne avec succès dans une seule usine apportant de nombreux avantages pour la production de DAP. Ces avantages comprennent:

- *Indépendance vis-à-vis de sources extérieures de vapeur*
- *Elimination des laveurs de gaz de queue*
- *Récupération améliorée d'ammoniac et de poussière d'engrais*
- *Conformité avec les normes d'émission aux Etats-Unis*
- *Réduction de la consommation d'eau dans les usines d'engrais*

Toutes les technologies ont été mises en oeuvre depuis plusieurs années et un système complet tel qu'il est décrit fonctionne depuis 1992. Pour des raisons économiques, la portion récupération de l'eau n'a pas été mise en oeuvre dans ce système mais il s'agit d'une partie peu importante de la technologie globale.

La technologie globale emploie de l'eau de recyclage pour les laveurs de particules (sécheur, poussière et refroidisseur) et le lavage à "double mol" suivi d'un vaporiseur/laveur pour le système R/G. Ce système permet à l'unité de DAP de coûter moins en capital, d'avoir des rendements plus élevés des éléments de procédé, de satisfaire les normes d'émission des Etats-Unis, et d'avoir un système avec moins d'entretien global.

Le système est applicable aux technologies de MAP et d'autres engrais ammoniés car il fonctionne dans un atelier qui produit à la fois DAP et MAP. L'aspect DAP du système est décrit car il est le plus susceptible d'application mais il peut être modifié légèrement pour fonctionner dans d'autres unités de phosphate d'ammonium.

Cette technologie doit être considérée pour une réhabilitation ou pour de nouvelles unités. Elle est applicable à toutes les unités mais, en particulier, en cas de graves pénuries d'eau.

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1. INTRODUCTION

This paper will present the history and development of a new technology which utilizes waste heat from an ammoniated phosphate plant to simultaneously vaporize the ammonia, scrub the fluorine containing off-gases from a part of the plant, and produce a reasonably pure, hot water stream for use in filter cake washing in the phosphoric acid plant. All of the components of this entire system have been utilized in ammoniated fertilizer plants since the early or mid 1980's and a full system as described has been in operation for the past two years.

2. BFL SYSTEM DEVELOPMENT AND HISTORY

In the early 1980's, Belladune Fertilizers of New Brunswick, Canada, was investigating methods of lowering the steam consumption at their DAP plant. Since this plant used spent sulfuric acid from an outside source, all steam was generated by burning fuel. Steam therefore had a real economic value to the plant. In most fertilizer complexes, the accounting department will transfer steam at a certain cost from the sulfuric acid plant to the other users. This cost, however, is not real money (cash flow) but is rather an accounting distribution of total plant costs. When a plant burns fuel to make steam, there is a real cost in cash flow money exiting the company.

In reviewing the overall DAP production process, the engineering group was examining if there was a way to utilize the low quality steam (atmospheric pressure, about 200 to 210 degrees F.) generated by the DAP reactor. At the completion of the study, it was determined that this low quality steam could be utilized to vaporize ammonia. The process ammonia is normally used at a pressure where the ammonia boiling point is about 50 to 80 degrees F. At this boiling point, the low quality steam has a high enough temperature differential to effectively vaporize the ammonia.

Belladune Fertilizers therefore installed a system with a shell and tube heat exchanger to vaporize the ammonia using the low quality steam produced by the DAP reactor. The steam was passed through the tube side of the vaporizer while the ammonia was input to the shell side of the heat exchanger. Controls were installed to allow only that amount of low quality steam required to pass through the heat exchanger and the balance of the reactor off gases to bypass the heat exchanger. This system was installed and started operation in 1981 and proved quite successful.

Belladune Fertilizers, Limited, obtained patents on this overall process in several countries including Canada and the United States. A Lakeland, Florida, USA, engineering firm, Bearden-Potter Corporation, was involved in several energy conservation projects for various fertilizer plants in the early 1980's. From their work in energy conservation projects, they learned of the Belladune Fertilizers, Limited, installation. After evaluating the technology, they negotiated a license for the technology with Belladune Fertilizers. For marketing purposes, the system became known as the "BFL Vaporizer System" and was presented to several fertilizer producers in the United States as an energy conservation modification. In the mid 1980's, Bearden-Potter installed two of these BFL Systems at the IMC fertilizer plant located in Central Florida (USA). These systems were essentially duplicates of the original installation at the Belladune plant and operated quite successfully.

In 1986, Bearden-Potter Corporation went out of business. Several of the engineers employed at Bearden-Potter formed a new engineering company in Lakeland, Florida, USA - HiTech Solutions, Inc. HiTech Solutions immediately negotiated with Belladune Fertilizers and transferred the license from the now defunct Bearden-Potter Corporation to HiTech Solutions, Inc. Marketing continued on the BFL system and another system was installed in 1991 at the J.R. Simplot fertilizer plant located in the State of Idaho, USA. This system was slightly different than the previous systems since all of the reactor off gases was passed through the tube side of the heat exchanger with none being bypassed. This modification simplified the control systems and lowered the cost of the installation. This system has operated successfully since start up and no control problems have been encountered as a result of the modifications.

3. DEVELOPMENT OF DOUBLE MOL SCRUBBING SYSTEMS

The initial scrubbing systems installed for DAP plants generally included scrubbing of the off gases from the following equipment:

- Reactor
- Granulator
- Dryer
- Dust System
- Cooler

In nearly all plants, the reactor and granulator off gases were combined into a single scrubber (referred to as the "R/G Scrubber") and the other streams scrubbed in separate units. Most of the ammonia vapor exiting the plant was in the R/G scrubber off gases while the other systems contained primarily fertilizer dust. All of the systems utilized the incoming low strength phosphoric acid as the scrubbing media.

During the 1970's, this system proved quite successful. The low strength acid from most plants was normally between 28 and 30 percent P_2O_5 and the split of incoming P_2O_5 between low and high strength acid was about one-half from each source. With the plant designs prevalent at that time and the plant rates in effect, the normal scrubber liquor from the scrubbing systems was 0.6 to 0.8 mol ratio (NH_3 to P_2O_5), the plant ammonia losses were acceptable, and the emission of fluorine from the plants was within allowable limits.

As rock quality declined, there were two major impacts on the phosphoric acid. First, the low strength acid declined to a normal 26 to 28 percent P_2O_5. Second, the higher amount of impurities lowered the normal strength of the evaporated acid from about 53 percent P_2O_5 to about 50 percent P_2O_5. At the same time, DAP plant production rates were being increased significantly with no modifications in equipment. As a result, by the mid 1980's, the mix of low and high strength acids incoming to the plant had shifted from an approximate 50 percent of the P_2O_5 from each to only about 25 percent of the P_2O_5 from the low strength acid. At the higher plant rates, the amount of ammonia to the R/G scrubbing system had increased significantly. These two modifications increased the amount of ammonia input to the R/G scrubber. The higher amount of ammonia input coupled with the lower amount of P_2O_5 raised the mol ratio of the scrubbing liquor which created operational difficulties and also increased the amount of ammonia lost to the atmosphere.

In order to improve the ammonia recovery, Richard McGinness of USAC fertilizers developed a system to rectify these problems. This system was the "Double Mol Scrubbing System" where the R/G off gases are scrubbed twice instead of just once. In this system, the R/G off gases are first scrubbed with a 1.4 to 1.5 mol ratio (NH_3 to P_2O_5) low strength (25 to 27 percent P_2O_5) to remove the majority of the ammonia. In this stage, about seventy percent of the total ammonia vapor is removed. A second stage scrubber then uses low mol ratio (about 0.6 mol ratio), low strength scrubbing liquor to remove the balance of the ammonia in the off gases. This system was found to have two major advantages:

- The overall ammonia recovery was significantly improved.
- The fluorine evolution into the gas stream was significantly reduced. Fluorine evolution is a function of scrubbing liquor temperature and the lower amount of ammonia reaction in the second stage scrubber reduced the fluorine evolution.

USAC made this technology generally available to all producers. It has been applied to several plants and was installed by Bearden-Potter and HiTech Solutions on their BFL System modifications as a part of the overall scrubber system design modifications. All of these systems have been in operation for several years with no major operational problems.

4. DESIGN AND OPERATION OF THE EARLY BFL SYSTEMS

With a typical DAP reactor, the slurry boils at about 230 to 260 degrees F. The heat of reaction (ammonia/phosphoric acid) is removed by boiling water from the slurry and venting the water vapor produced from the reactor. In most plants, the off gas contains about one pound of water vapor per pound of dry air. As a result of the vapor pressure of ammonia over the boiling slurry, the off gas also contains about 0.05 pound of ammonia vapor per pound of water vapor.

In a typical plant, this gas stream is combined with the off gases from the granulator and the combined gas stream is scrubbed using the incoming low strength phosphoric acid. This scrubbing action removes the ammonia vapor and fertilizer dust in the gas stream. When examining the reactor off gases, the gas stream is close to saturation. Normal saturation is 185 to 190 degrees F. Since the process ammonia will vaporize between 30 and 70 degrees F., there is sufficient temperature differential between the reactor saturation temperature point and the ammonia vaporization point to economically size a heat exchanger. The ammonia flow is controlled into the vaporizer by any one of several control schemes and the hot reactor off gases vaporize the ammonia by condensing a portion of the water vapor in the off gas. If all of the ammonia is vaporized in the BFL heat exchanger, the total off gas temperature will be reduced from about 190 degrees F. to about 180 degrees F. (saturated).

In the original system, the flow of reactor off-gases to the heat exchanger is controlled by a damper in the inlet stream. A second damper controls the amount of reactor off gases bypassing the heat exchanger. This control system was implemented to minimize heat exchanger size and to use ammonia level control in the heat exchanger. The two systems installed by Bearden-Potter continued this same control scheme.

For start-up purposes only, a steam line is installed and manually opened to provide supplemental heat to the gas stream so that the ammonia in the BFL vaporizer can be vaporized. This start-up steam is only required if attempting to start the plant at a high rate (near nameplate) and then only for a period of about ten minutes or less. If the plant is started at about one-half nameplate rating, no steam is required.

In normal operation, the ammonia liquid level is less than fifty percent and the ammonia vapor superheats in the top half of the heat exchanger. Ammonia vapor exiting the heat exchanger to the granulator and the reactor normally has up to one hundred degrees of superheat. In general, this amount of superheat has not been found to be detrimental to the process. In fact, with phosphoric acids produced from some rock sources (for instance, western United States rock), the superheat is required for the process to operate properly.

The heat exchanger is oriented vertically and the reactor gases flow down through the tubes. As the ammonia is vaporized, a portion of the water vapor in the gas stream condenses and is separated from the off-gas stream by an impact chamber under the heat exchanger. Since the reactor off-gas stream contains ammonia vapor from the reactor, the condensed water will contain from one to three percent ammonia depending on the exact operating conditions. This stream contains too much ammonia to discard and was used internally in the plant.

In the Idaho installation, HiTech Solutions examined the control scheme in light of the need to maximize superheat and decided to pass all of the reactor off-gases through the heat exchanger. The ammonia control scheme was redesigned to minimize level and allow the maximum of ammonia vapor superheat. Although design calculations indicated that the ammonia vapor would exit the heat exchanger with approximately 140 degrees F. of superheat, the actual operation has only achieved about 110 degrees F. of superheat. Other than not achieving the design superheat, the system has operated successfully and the change in the control scheme has proven successful.

5. DESIGN AND OPERATION OF THE DOUBLE MOL SCRUBBING SYSTEMS

As the amount of ammonia vapor to the single stage R/G scrubber increased and the amount P_2O_5 decreased, the heat release of the ammonia/acid reaction in the R/G scrubber would raise the temperature of scrubbing liquor exiting the R/G scrubber to about 220 to 225 degrees F. At these temperatures and mol ratios, the ammonia absorption efficiency would decrease to 90 percent or less. Simultaneously, these high liquor temperatures caused the amount of fluorine evolved from the liquor to increase. Unless a secondary water scrubber for fluorine (tail-gas scrubber) was present on the R/G gas stream, the plant would frequently be out of fluorine emission compliance.

USAC therefore examined the problem and installed a system to react a significant portion of the ammonia at conditions that would improve ammonia absorption efficiency and also reduce the fluorine evolution. A small scrubber was installed on the R/G off-gas stream ahead of the existing R/G scrubber. This scrubber consisted only of duct sprays to contact the scrubbing liquor and the R/G off-gases. The duct sprays were followed by a small cyclonic separator to separate the majority of the liquor from the gas stream. This liquor was then drained to a small recirculation tank.

The mol ratio in this tank was controlled to about 1.4 to 1.5 by inputting a portion of the phosphoric scrubbing liquor while simultaneously transferring the high mol liquor to the reactor. The balance of the phosphoric scrubbing liquor was transferred direct to the reactor.

The expected results of this modification were several fold. First, the high mol ratio acid would react a significant amount of the ammonia vapor and lower the temperature of the scrubbing liquor in the existing R/G scrubber (now called low mol scrubber). Second, the fluorine compounds tend to be complexed with ammonia at the higher mol ratios and have significantly lower vapor pressures. The evolution of fluorine should therefore be reduced since there would be little fluorine evolution in the high mol scrubber and less ammonia reaction in the low mol scrubber where the fluorine will evolve. Since ammonia scrubbing efficiency is a function of the partial pressures of ammonia in the gas stream, the partial pressure of ammonia into the low mol scrubber would be reduced and the ammonia recovery would increase.

This system operated slightly better than forecast. HiTech Solutions has installed several of these scrubbing systems and found that the overall ammonia efficiencies are excellent and there have been no operational problems. The only real changes to the retrofitted systems by HiTech Solutions and the original installation at USAC is the sizing of the vessels.

6. DEVELOPMENT OF OVERALL BFL SCRUBBING SYSTEM

The inherent characteristic of the BFL System that limited its application to fertilizer plants was the disposal of the condensed water stream from the heat exchanger. As previously mentioned, the condensed water stream may contain from one to three percent ammonia by weight. Although the exact amount of water condensed varies slightly depending on operating conditions, the design average is 230 pounds of water is condensed per ton of DAP product. At two (2) to seven (7) pounds of ammonia per ton of DAP product, the ammonia content is high enough that the water stream must be consumed internally in the plant. This internal consumption limited the real energy benefit by requiring a higher incoming acid strength to maintain the overall plant water balance.

HiTech Solutions had been examining this problem for several years and had tried various laboratory experiments to recover the ammonia without consuming the water stream. In general, it was found that the ammonia could be stripped but the economics of the stripping plant detrimentally affect the overall economics. HiTech Solutions therefore began examining the overall scrubbing system to determine if there was reason for a major modification to the overall BFL System to eliminate this water problem.

HiTech Solutions had installed several double mol scrubbing systems on various plants including those that had the BFL System installed. In examining the overall theoretical calculations, it became obvious that relocating the BFL heat exchanger to a position downstream of the R/G acid scrubbing system would alleviate the ammonia in the condensate problem. A heat and material balance indicated that the scrubbed gases exiting the second stage scrubber of the double mol scrubbing system would still be at between 180 to 195 degrees F. depending on exact operating condition. These gases would be approximately saturated with respect to the water partial pressure over acid at that temperature. Based on the acid strength, the off-gases would be at about eighty percent relative humidity and would contain about 0.7 to 0.8 pounds of water vapor per pound of dry air. Only traces of ammonia would remain since the gases were exiting the ammonia scrubbing section.

Locating the BFL ammonia vaporizer after the acid scrubbing section would still provide sufficient heat to the ammonia to have complete vaporization and would simultaneously allow the condensed water stream to be discharged from the plant to the contaminated water section. The amount of ammonia is so small that no economic reason exists to recover the water stream. This modification to locate the heat exchanger downstream from the acid scrubbing system would eliminate the primary restraint that had hindered acceptance of the BFL System technology.

In a normal DAP or MAP plant, there are four primary scrubbing systems:

- Dryer Off Gases
- Reactor/Granulator (R/G) Off Gases
- Dust System Off Gases
- Cooler Off Gases

When fluorine emissions are examined, about one-half of the emissions come from the R/G system and the other half comes from the other three systems combined. In most United States plants, the "Best Available Technology" (BAT) has been to install one or more tail-gas scrubbers on all of the exiting gas streams. These scrubbers use once through acid pond water to remove fluorine from the gas streams and meet air emission standards. In general, the only off gas stream that can be proven to require such a tail-gas scrubber is the R/G System.

In examining the vapor pressure curves for fluorine over water, calculations indicated that the condensed BFL vaporizer water (when the heat exchanger is located after the double mol scrubbing system) would absorb enough fluorine vapor that the emissions of fluorine from the plant would meet United States EPA standards with no tail-gas scrubbers. This represents a significant capital and operating cost savings.

On the basis of the above calculations and revisions to the BFL System, HiTech Solutions began to promote the new system.

7. GRANULAR PLANT INSTALLATION

When Farmland Hydro, L.P. was considering a significant modification to one of their granular fertilizer plants, HiTech Solutions, Inc. was contracted to evaluate the plant, recommend improvements, and then engineer the final selected design modifications. Farmland Hydro, L.P. personnel had extensive experience and test data regarding the effect of condensing water in fluorine vapor containing stream. On the basis of their experience, Farmland Hydro, L.P. accepted the basic calculations, examined the economics, and decided to proceed with the installation of the modified BFL System where the heat exchanger acts as a scrubber/vaporizer.

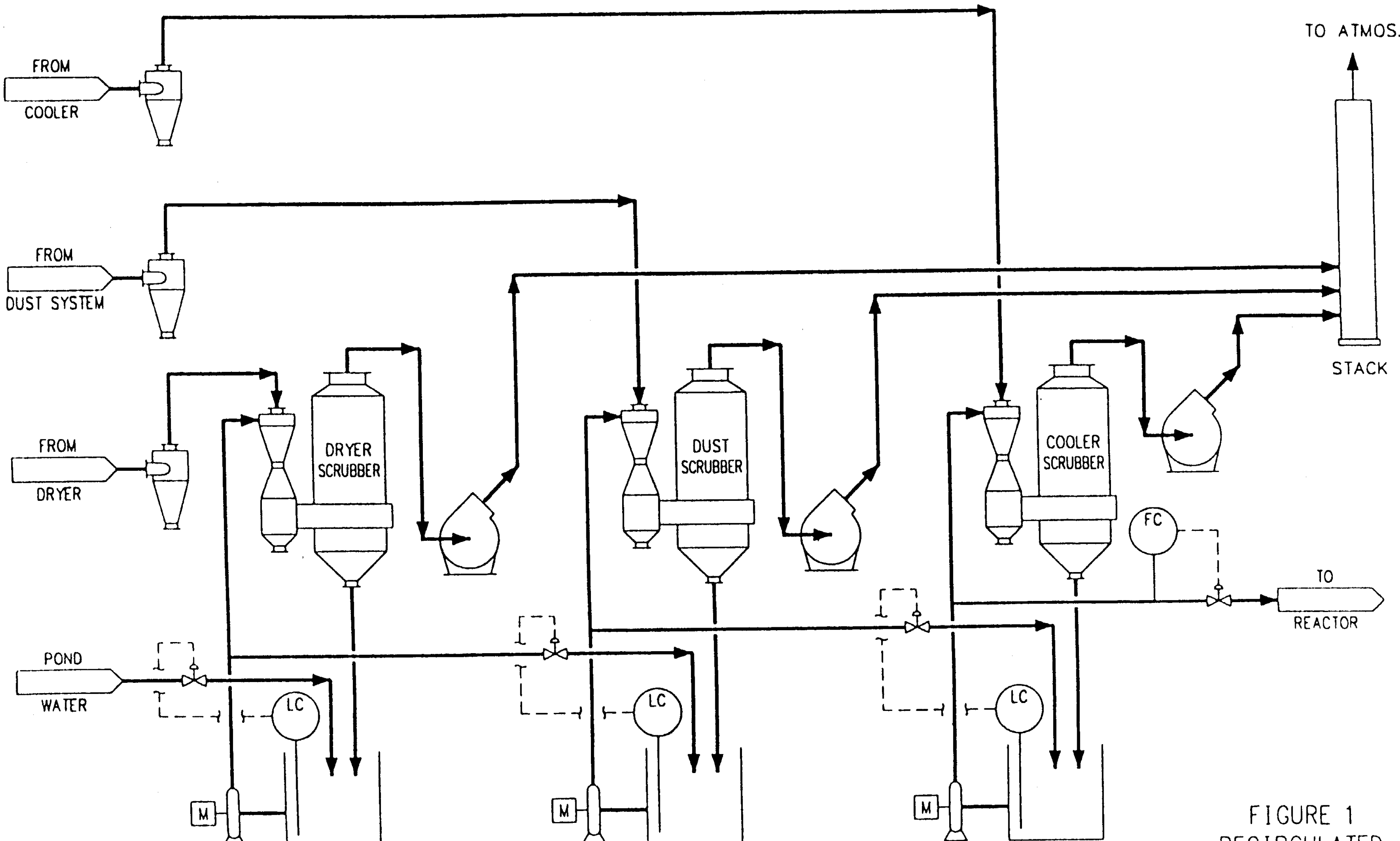
7.1. INSTALLATION DESCRIPTION

The entire project at the Farmland Hydro, L.P. plant made numerous process modifications which are beyond the scope of this paper. This discussion will center upon the scrubber modifications and specifically the revised BFL System installed.

The dryer and dust scrubbing systems had previously been operated by recirculating low strength acid which was also used in the R/G scrubbing system. Scrubbing of these off gas streams is primarily done to capture fertilizer dust. There is a small amount of ammonia, but it represents only about two percent of the total ammonia in all off-gas streams. Calculations indicated that the acidic pond water utilized in most plants would be capable of absorbing the small amount of ammonia and would perform satisfactorily in removing the fertilizer dust from the off-gas streams. Since pond water has a significantly lower vapor pressure of fluorine, less fluorine would be evolved into the gas stream and no tail-gas scrubber would be required.

The scrubber water is then consumed in the reactor and the fertilizer dust is reclaimed. The quantity of water consumed does mean that a slightly higher blend acid strength is required for plant input but the economics favor using water to reclaim the fertilizer and not installing a tail gas scrubber on these scrubbers. As part of the expansion, a cooler scrubber was added to the plant and it also used recirculated water for scrubbing liquor. **(See Figure 1.)**

Other than changing the scrubbing liquor, the dryer and dust scrubbers were unchanged. As part of the overall modifications, a new cooler scrubber was installed and it was included with the dryer and dust scrubbers as a recirculated water scrubber. The existing R/G scrubber system was removed and replaced with the double mol scrubbing system followed by the BFL vaporizer/scrubber.



NOTE: MAY USE ONE TANK IF LAYOUT PERMITS.

FIGURE1 05/31/94 @ 09:37 DR

Drawings by H/TECH SOLUTIONS, INC. Lakeland, Florida

FIGURE 1
RECIRCULATED
PONDWATER SCRUBBERS

In the double scrubbing system, the granulator and reactor off gases are each scrubbed separately with duct sprays (See **Figure 2**). This separation is a function of the layout and is not mandatory to the system. Scrubbing liquor flow rate is about 8 USA Gallons per 1,000 cubic feet. Both duct systems enter a cyclonic separator where the liquor is separated from the gas stream. The liquor drains back to a recirculation tank. The gases then enter a Venturi scrubber (about twelve inches water column delta P) followed by a cyclonic separator. This scrubber uses low mol scrubbing liquor and is designed to remove all of the fertilizer dust and the remaining ammonia vapor. The low mol liquor drains back to a recirculation tank.

All incoming low strength phosphoric acid is flow controlled to the low mol tank. A portion of this liquor is transferred to the high mol tank and the balance is transferred directly to the reactor. The amount to the high mol tank is controlled by analysis of the high mol scrubbing liquor. The transfer amount keeps the mol ratio at 1.4 to 1.5 mol ratio.

The off-gases from the low mol scrubber enter the BFL Heat exchanger. All of the condensed water is drained to a seal tank and recirculated to a single large spray nozzle at the heat exchanger inlet. This spray was installed to minimize the tubeside build up and keep the heat exchanger clean. The off-gases flow down through the heat exchanger and the gas stream/condensed water enters a separator chamber equipped with a chevron style demister to minimize the mist carryover to the fan. At the Farmland Hydro plant, the condensate is simply discharged into the plant acidic water system for disposal.

7.2. <u>OPERATIONAL HISTORY</u>

This system was started up in September 1992 and has been in continuous operation since that time. This plant was designed to produce both DAP by the slurry process and MAP by the pipe reactor process. In addition, the ammonia system controls are extremely complex since the ammonia is used first as a refrigerant in the cooler chiller and then proceeds to the BFL vaporizer.

Since start up, the plant has had no difficulties when producing DAP. The system has vaporized the required amount of ammonia and met all of the regulated emissions for particulate (fertilizer) and fluorine. With MAP, the amount of ammonia vapor from the plant to the scrubbing system has been considerably less than forecast and this has created some problems with meeting the fluorine emissions. A system has been installed to add additional ammonia to the R/G gas stream and maintain the mol ratios required and this has allowed the plant to achieve the required fluorine emission limits.

Because of the complexity of the ammonia controls, there have been problems with ammonia control when making changes in rate but the system has been stable when at a constant rate. This problem is unique to the extremely complex control system installed at this plant and is not a function of the new BFL vaporizer/scrubber system.

The BFL condensate has consistently been delivered to the pond system at a temperature of about 180 degrees F. with a low concentration of ammonia, phosphorous, and fluorine. This water could be used internally in the plant or in the phosphoric acid plants but was not used since the economics of recovery at this existing plant with the pond system were not favorable.

During the design stage, there was considerable concern on the part of all parties concerning possible build up in the heat exchanger. This concern was addressed by designing an extremely efficient cyclonic separator for the low mol scrubber to virtually eliminate mist carryover and by installing the BFL heat exchanger recirculation system. Since start up, there has been no noticeable build up in the heat exchanger. However, the corrosion rate of the 316 Stainless Steel tubes has been higher than forecast. At present, the expected tube life is forecast at about five years instead of the expected seven to ten years.

In general, the system has operated successfully and has met the emission limits imposed.

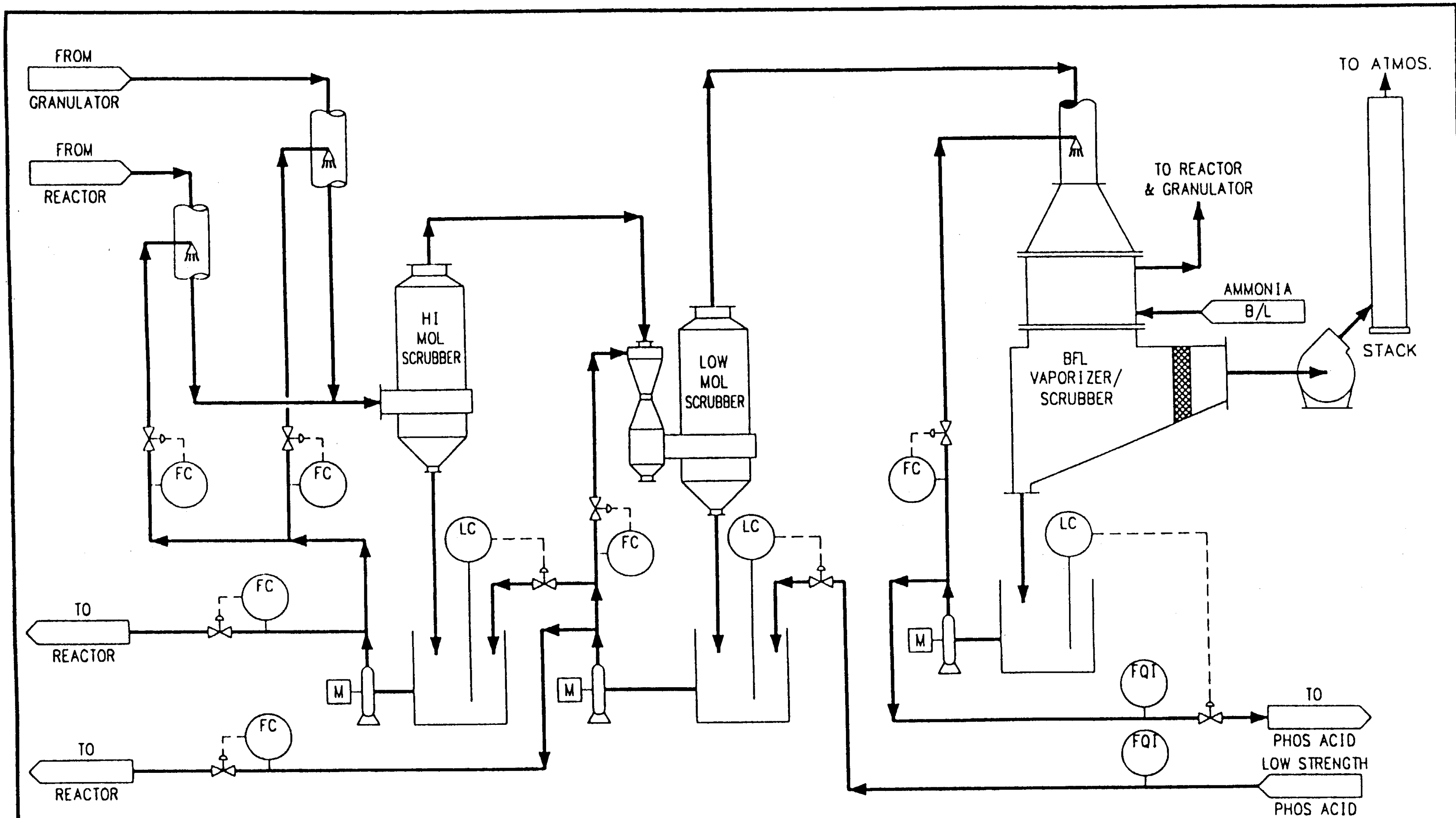


FIGURE 2
R/G SCRUBBING
SYSTEM

Drawings by HiTECH SOLUTIONS, INC. Lakeland, Florida

FIGURE2 05/31/94 @ 09:56 DR

8. OPERATING DATA (DAP)

The initial plant design had about thirty percent of the P_2O_5 delivered as low strength acid to the low mol scrubber. This design point has generally been met but is strictly a function of the incoming acid strengths. Of the total volume of low strength acid, about one half is transferred to the high mol scrubber. This varies considerably with the plant operations and is strictly a function of the amount of ammonia vapor input to the double mol scrubbing system.

In the United States, DAP plants are presently regulated for air emissions concerning:

- Fluorine
- Particulate
- Opacity

Ammonia limitations are presently being imposed but there is not yet a regulated ammonia limit. Present United States limits are all based on the input of P_2O_5 to the plant and are:

1. Fluorine - 0.06 pounds of F per ton of P_2O_5 (total, all stacks).

2. Particulate - negotiated but not exceeding 1.0 pounds per ton of P_2O_5 (total, all stacks). Best Available Technology (BAT) applied to new sources would be limited to about 0.2 pounds per ton of P_2O_5 (total, all stacks).

3. Opacity - Not to exceed 20 percent.

4. Ammonia - Most negotiations at present are looking at 98 to 99 percent recovery of total ammonia input.

The above regulations are typical of the permit obtained by Farmland Hydro for their modified plant. To date, the new systems installed have been capable of meeting the permitted requirements.

Typical operating conditions for DAP have been:

Low Mol Scrubber

Mol Ratio:	0.4 to 0.8
Scrubbing Liquor Temperature:	about 160 degrees F.
Recirculation Ratio:	12 gallons (USA) per 1,000 cubic feet of off gas
Scrubber Gas Exit Temperature:	180 to 195 degrees F.

High Mol Scrubber

Mol Ratio:	2 to 1.6
Scrubbing Liquor Temperature:	about 185 degrees F.
Recirculation Ratio:	10 gallons (USA) per 1,000 cubic feet of off-gas
Scrubber Gas Exit Temperature:	180 to 195 degrees F.

BFL Vaporizer/Scrubber

Entering Gas Temperature:	180 to 195 degrees F.
Exiting Gas Temperature:	170 to 185 degrees F.
Recirculation Ratio:	Constant at about 300 gallons (USA) per minute
Condensed Water Temperature:	Same as gas stream
Condensed Water Composition:	0.02 to 0.2 percent F; less than 2,000 ppm of ammonia; less than 1,000 ppm of P_2O_5
Condensed Water Amount:	About 0.45 gallons (USA) per ton of DAP product rate

R/G Emissions:

Confidential, but have met all regulated amounts.

9. APPLICATION TO OTHER COMPLEXES

HiTech Solutions, Inc. believes that all parts of the overall fertilizer scrubbing strategy presented in this paper are well proven technologies. These include:

1. The water scrubbing of the dryer, dust, and cooler scrubbers has been in operation since the early 1980's and has proven successful at removing the particulate with little fluorine evolution. No tail-gas scrubber is therefore required on those off-gas streams.

2. The BFL vaporizer concept is in operation on several plants world wide and has been successfully in operation since 1981. This concept removes the need for an outside steam source for process operations.

3. Double Mol Scrubbing has been in operation since the mid 1980's at several plants and has proven successful in minimizing the evolution of fluorine while improving the ammonia recovery from the R/G gas stream.

4. And, finally, the new BFL scrubber technology described in this paper has been in operation successfully for two years.

Applying all of these scrubber technologies to DAP plant produces many benefits to the operator. Among these benefits are:

FREEDOM FROM OUTSIDE STEAM SOURCE

Since self-generated steam is utilized to vaporize ammonia, the DAP plant is not dependent upon steam from the sulfuric acid plant nor from a boiler. While supplemental steam allows a more rapid start up, there is sufficient heat to allow a slow start up with no need for supplemental outside steam even at start up.

ELIMINATION OF TAIL-GAS SCRUBBERS

In a typical DAP plant with tail-gas scrubbers using acidic pond water, there is a once through pond water system supplying 10,000 gallons (USA) per minute (GPM) of pond water and also returning it to the pond. Given normal pond water pressures, eliminating this system saves about 500 HP for water pumping only at a 5,000 GPM recirculation rate. The elimination of the tail-gas scrubbers also eliminates a constant maintenance problem since these scrubbers are prone to pluggage and cleaning problems.

HIGHER RECOVERIES

With the Double Mol scrubbers and water scrubbers on the other off-gas streams, particulate recoveries will be in excess of 99 percent (based on input to scrubbers) and ammonia recoveries will be greater than 98 percent (based on total ammonia to plant). In general, these scrubbers have proven trouble free and have lower maintenance than older technologies.

MEET UNITED STATES AIR EMISSIONS

Besides the United States, many other countries are using these emission standards as a guideline for fertilizer plants. This technology is proven and has shown the ability to meet these emission standards. The technology is economical and reduces overall capital cost compared to tail-gas scrubbers or other technologies available.

MINIMUM WATER CONSUMPTION

For every ton of DAP produced, about 0.45 tons of water is used to dilute the incoming phosphoric acid to the proper strength. If the BFL vaporizer/scrubber condensate is pumped back to the phosphoric acid plant and used for filter washing, about eight (8) percent of the total water is then recirculated. If this is combined with the elimination of tail-gas scrubbers and their water consumption, then the total water consumption for the fertilizer complex can be significantly reduced.

HiTech Solutions, Inc. has presented its available a proven technology for DAP plants to significantly reduce capital, maintenance, operating costs, and water consumption. This technology should be carefully considered for all fertilizer plants.