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Spring/Summer 2015

Mosaic's New Wales Plant: bringing a world-class legacy into the 21st century

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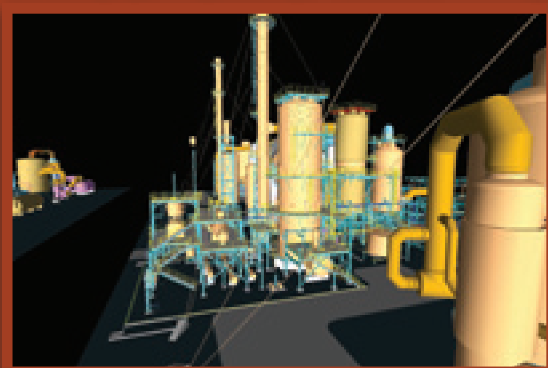

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Mosaic's New Wales Plant: bringing a world-class legacy into the 21st century

The world's population is estimated to be about 7 billion people, with another 150,000 people born every day. Combine those statistics with limits on farmable land, and you get a powerful demand for productive soil. Understanding these forces, strategic planners at Mosaic Co., the world's largest producer of phosphate fertilizer, are investing billions of dollars in the company's phosphate- and potash-based fertilizer operations, including the flagship New Wales phosphate facility in Mulberry, Fla.

The New Wales plant was built in 1975 as a state-of-the-art facility and at the time was the largest phosphate fertilizer complex in the world. Before Mosaic purchased it, the facility was owned by IMC Global Inc., which operated several plants in Florida and Louisiana. IMC Global had a long history dating back to 1909, and grew to be a major player in both phosphate and potash fertilizers.

Mosaic began operating in 2004, as a merger between IMC Global and another internationally recognized leader in industrial fertilizers, Cargill Crop Nutrition. Cargill Crop Nutrition began in the 1960s as a division of Cargill, Inc., a leading agribusiness company. From there, the division grew to be one of the world's top producers of phosphate and nitrogen fertilizers.

Today Mosaic, headquartered in Plymouth, Minn., leads the industry in worldwide phosphate production at 11 million tons annual capacity and is a major global producer of potash at over 10 million tons. To achieve these volumes, the company employs nearly 9,000 individuals to work in over a dozen large-scale mining and production facilities and multiple distribution centers and offices worldwide.

The New Wales facility, though no longer the largest fertilizer plant on the globe, is well-positioned to continue its world-class legacy. As a proven high-volume, lower-cost performer among Mosaic's phosphate facilities, the company has invested hundreds of millions of dollars to keep New Wales world-class as it moves into the 21st century.

Additional steam supply for the high efficiency steam injection system is generated by an LLP Boiler which recovers additional heat from the HRS acid to generate 15 psig steam.

The last of the 5 stacks is replaced during the 45-day 01 Plant turnaround that started in January 2015.

Much of this investment you can plainly see. Walk through New Wales' sulfuric acid operations today and you will witness the progress of a major capital investment plan that, when completed, will have replaced every major component of all five sulfuric acid plants. You will also notice two new heat recovery systems (HRS) and two new steam turbine-generators, one installed in 2009 and the other one last year.

Putting the "Continuous" in Continuous Improvement

For all of New Wales' tangible enhancements, equal focus has been placed on improving the sulfuric acid department's processes and organizational structure. In fact, New Wales has been analyzing every aspect of its sulfuric acid department: operations and maintenance, OEE, maintenance reliability and mechanical integrity, asset management, staffing, role definitions and training, safety—and more. Getting and keeping New Wales at world-class performance levels through this century means creating a continuous improvement culture and committing to supporting it for the long term. Not a once-and-done process, but a cyclical one: analyze your process, refine your process, do your process. Repeat.

A key contributor to New Wales refining its organizational practices is the installation of a dedicated Continuous Improvement (CI) group. Because the CI group's singular focus is to optimize the facility, it can objectively help problem solve across departments. Ky Phan, Continuous Improvement Manager at New Wales, puts it this way. "The only skin I have in the game is to help the plant improve. And sometimes it takes an objective group to get all the right experts from the different teams together to get to the root of the problem."

And often it takes the CI groups' focused approach to hone in on the issues amid all the activity involved with operating five acid plants, three generators and multiple utility systems. "There is a lot going on in a plant this size with the different groups always looking at safety, cost, production, quality, environmental and so forth," Phan says. "The CI group's job is to penetrate beyond these routine activities to help identify root causes, facilitate solutions and drive them to closure with long-term solutions rather than temporary fixes."

"Much of what we do sounds simple; and it is," Phan continues. "But the problems are never really simple. There are always multiple causes that take time and discipline to resolve." With three years at New Wales under his belt, Phan and his team have earned recognition as a value-add component of the facility. But it wasn't always that way.

"New Wales has seen a lot of improvement plans come and go over the years," says Phan. "In the past, a team would spend months doing reviews to improve OEE, maintenance reliability, turnaround management, costs, safety, workflow, etc. Then the commitment to support the recommendations would disappear as soon as the company moved on to a new area of focus. Lots of good work was done to identify and solve problems, but there wasn't the essential organizational support to maintain the solutions for the long term."

But all that has changed since Mosaic took over and implemented this CI effort. "The CI team has helped us tremendously," says Keith Willis, Sulfuric Acid Area Manager. "They've helped us get better organized, stay focused and maintain the discipline to follow our procedures. They've put the systems and the metrics in place. They've gotten the operators recognition from management for being an integral part of the process. They've helped clearly define all the roles in this facility and how everyone at all levels contributes to the overall plant and corporate goals."

The CI team's influence includes another important dimension—management support. "Beyond the tools to help the plant identify its problems," says Willis, "now for the first time the CI group can really deliver the management support—whether that is capital funding, staffing, or organizational standards and policies—in a way that has not been seen in the past at New Wales."

"It's been rewarding to see that Mosaic recognizes the value of continuous improvement," Willis says, "and has made the long-term commitment to ensure the continuous part of continuous improvement is there."

Sustaining capital investments

Mosaic's long-term commitment is also evidenced by the capital investments it has been making to the New Wales facility. And with five acid plants, that means a lot of capital. As the sulfuric acid plant equipment originally installed in the mid-1970s began approaching 25 years' service life, a long term capital equipment replacement plan became imperative.

When the plan was first being developed, a process analysis was conducted to optimize the performance of each new piece of equipment, as opposed to simply replacing old assets with new. Steam turbine and blower efficiencies were improved; cast iron grid and post converters were upgraded to stainless steel radial flow designs; and carbon steel brick-lined acid towers with cast iron distributors became alloy towers with high efficiency distributors, low pressure drop structured packing, and the latest mist elimination technology with concentric auto-drain candle designs. All of the heat exchange equipment designs, from boilers to economizers, to gas-gas heat exchangers, to acid coolers have been optimized as well.

"It's been a long program, but the results have been exceptional," says Jim Dougherty, New Wales Process Engineer. "These upgrades not only returned all of the assets to their original operational integrity, but have also increased production capacity and improved energy recoveries. On top of that, the plants also operate with even lower emission rates than the original designs did."

Why not just fix the equipment? It's all part of Mosaic's long-term philosophy.

"Mosaic believes in the phosphate business, and is investing heavily for the future," says Chris Hagemo, Assistant Facility Manager at New Wales. "We are deploying significant capital to not just fix what we have, but to make things better. We'll get 20 to 30 more years of solid performance out of this equipment."

The equipment replacement count is impressive: 5 each of major components such as furnaces and converters; 10 waste heat boilers; 15 acid towers; 18 acid coolers and 25 super heaters and economizers. And when you include the more routine equipment like pump tanks and stacks, the grand total exceeds 90 pieces of major equipment.

Super-sized turnarounds

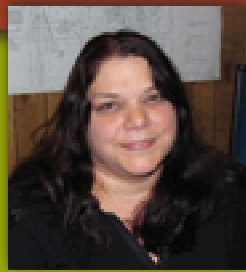
With all the new capital equipment and the heat recovery installations, New Wales has been experiencing the most complex turnarounds in its history. "The turnarounds here are the largest I've seen


Chris Hagemo


Chris Pearson


Dennis Sisco


Jim Gruber


Kristi Farrell


Installation of new 4A/C economizer — 4A superheater installed at 02 Plant. The equipment was designed by MECS/DuPont and fabricated by Optimus.

in my 25-year career," says Willis. "The coordination between the project group, the operations group and the engineering group has to be spot on. And while we're doing a turnaround on one of the acid plants, we're still operating four other plants and three generators."

A normal New Wales turnaround used to take two weeks, and might include screening catalyst, a little maintenance on acid distributors and brick refractory, water blasting acid coolers, cleaning boiler and heat exchanger tubes and maybe replacing a gas duct or two. Then, when the capital equipment replacement funding started coming in, things changed. "We've had to reinvent how turnarounds are handled here," Hagemo says. "How we've choreographed outages from staffing, planning and logistics is a testament to the hard work and efforts of the entire sulfuric team."

"When we first started executing the equipment replacement plan, replacing just one piece of equipment, such as an acid cooler or a gas-gas heat exchanger, was a big task. Each time, we had to figure out the best way to do the work for each piece of equipment," recalls Dougherty. Then things began to accelerate. "We moved on to bigger scale equipment, like furnaces and acid towers, and then ultimately the first converter change-out. That was a really big deal for us—28 days."

But the work intensified even further. "So much so," recalls Capital Projects Manager Atusa Amiri, "that it is hard to remember what a turnaround with only one or two equipment replacements was even like. We progressed to multiple project turnarounds, like a new converter with an acid tower and two gas-gas heat exchangers. After so many of these," Amiri continues, "the norm became replacing 3-5 pieces of equipment every turnaround. We had to find a way to get ahead of the game. Ultimately we ended up with a 10-year sulfuric acid capital equipment plan to lay out which equipment made the most sense to change together based on New Wales' 5-year capital funding plans. I was developing and securing funding for projects 3-4 turnarounds into the future, all while executing 3-5 piece turnarounds every 6 months."

For the sulfuric operations and maintenance group, the frequency and duration of the turnarounds compounded the complexity further. "We were doing these big turnarounds every six months and many of them were nearly a month long," explains Willis. "So that means we were almost always either working on turnaround prep, in turnaround, or in the post-turnaround demobilization stage. Eventually we got to the point where turnaround mode was the only mode we had."

"Fortunately," says Hagemo, "by the time we started getting into these multiple equipment turnarounds, we had already developed enough experience performing single-equipment replacements that the larger projects came down to proper planning and coordination."

The turnaround complexity ultimately peaked in 2014 with back-to-back turnarounds installing 5 pieces of equipment during each outage plus heat recovery system (HRS) conversions, and the commissioning of a 30 megawatt (MW) turbine generator in between. Finally, the most recent turnaround spanned 45 days and consisted of 9 major equipment replacements—a furnace, two waste boilers, drying tower doghouse and mist eliminators, two economizers, a superheater and two acid coolers. "We're looking forward to getting back to those "easy" 2-3 equipment turnarounds again," says Willis.

Managing turnarounds—hitting the bull's eye

With the scope of the turnarounds and all the different groups wanting to perform capital replacements, maintenance reliability and traditional turnaround work during the same outage time, Operations Turnaround Coordinator Keith Eldridge's role became more critical than ever. "I coordinate the logistics of all these teams coming together," Eldridge says. "So I developed a plot plan to track all the different contractors coming in for all the various projects. Who is coming in when, when is a certain contractor available, what equipment are they bringing, what crane size are they using, will it fit, what roadways are we closing for those 12 concrete trucks coming in, is there enough parking, how do we give access to the 300 additional people moving in and out, do we hire a full-time person to direct traffic, how much waste are we generating, how are we handling that and so forth."

"These turnarounds became complex, but they still had to execute perfectly. It's like having to hit the bull's eye every time," Eldridge says. "But, hey, that's what we're aiming for."

Helping him hit that bull's eye are two dedicated planners, Mosaic's Jai Jairam, and Central Maintenance and Welding's Walter Brown. "I spend nearly all of my time here at New Wales planning and scheduling turnarounds," says Brown. Together with Mosaic, Brown has taken the best practices from past turnarounds and developed a New Wales-style turnaround planning system that uses templates and an optimized sequence of procedures. Brown also combines all the contractors' schedules and gets daily contractor updates, which he includes in the master schedule and redistributes.

"Tracking progress is critical," Brown says. "In order to try to bring things in, you have to know whether you're getting behind. People need interim goals on their way to achieving the end goal. It used to be we'd have just the one end date. Then the tasks in the middle would keep slipping out farther until you'd push the end date."

Given the significant price tag associated with each super-sized turnaround, New Wales has also been working diligently to extend the time between outages. The original turnarounds back in 1975 took place every 9 months driven by the need to screen the old pellet style catalyst. Then, with the advent of low pressure drop ring catalyst, a 24-month operating cycle became commonplace. Eventually they were increased to 30 months. But even the 30-month cycle is under scrutiny as the team considers the feasibility of extending to a reliable 36-month operating cycle.

"We've looked at the economics of taking just a few days to do a simple turnaround—screen catalyst and maybe check distribution levels in the towers," says Hagemo. "But even that bit of work can cost \$2.5-3 million, so we found it makes better financial sense to extend another 6 months and save half a million dollars."

Pushing turnaround cycles even further means the diligent every-day operating paradigm of continuous improvement is even more important. "Longer operating cycles means we have to run the plants even better in between," says Hagemo. "Proactive maintenance reliability is critical."

"We are in this culture now of finding sustainable solutions to reduce expenses, improve performance and improve reliability," Hagemo continues. "We're questioning historical operating paradigms. And we've been successful. When we went to a 30-month turnaround cycle, folks were saying, 'you can't run an HRS plant past 24 months,' but we did. We'll see whether we can continue in the long-term, but we'll keep searching for those bottle necks and stretching ourselves as long as we can."

Although the New Wales team with its five acid plants executes turnarounds every 6 months, for Mosaic as a whole, it's an even bigger story. In central Florida, Mosaic now operates a total of 17 sulfuric acid plants, all of which share the same contractors during turnarounds. With this many plants and a limited set of qualified local contractors, coordinating all of the acid plant turnarounds has become a monumental task.

In front of that task is Turnaround Maintenance Advisor Dennis Sisco, also known locally as "the turnaround guy." A huge proponent of planning, Sisco has formalized a Mosaic-wide turnaround management program and helps facilitate execution of that process at all of the sites, particularly the sulfuric acid plants. A central theme to his work is sharing information.

"We've looked at all the sites, capturing what they're doing well and what they can improve, and taking that from site to site, so that everybody gains from the tribal knowledge of all the teams," says Sisco.

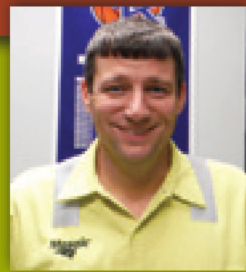
A common issue Sisco has noticed throughout has been too few quality contractors to perform all the work at Mosaic's 17 acid plants. And the contractors they are using are stretched to capacity.

"This year, we're conducting nine sulfuric acid turnarounds," Sisco says. "A record for Mosaic. And if we're using the same contractors for all of them, the crews get worn out. We're looking into ways of requiring them to take time off every so often, rotating crews, and even rotating contractors so we don't burn out any particular contractor and get better, safer performance overall."

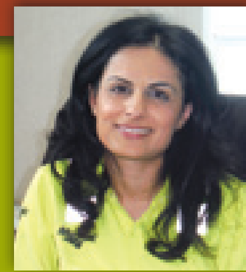
Securing safety—"priority #1"

Given all the considerations regarding turnarounds, there is one area that has risen above all others—safety. "The safety turnaround management plan is fully integrated to the plant's planning process from day one all the way through to the final turnaround audits," explains New Wales Manager for Health, Safety and Security, Joe Alderdice. "All the contractors for the

Ky Phan



Joe Alderdice



Atusa Amiri

Jai Jairam

Jim Dougherty

major projects provide a detailed safety plan as part of the bidding process and the quality of these plans is critical to contractor selection. Once all the contractors are selected, the plans for each contractor's job are integrated into an overall safety plan that becomes the core of all of the other turnaround planning activities. This approach becomes all the more critical as the turnarounds became longer and more complicated."

As important, if not more important than these critical planning tasks are the activities Mosaic has developed over the years to establish a direct point of contact with every contract employee in every turnaround every day. "A pre-turnaround safety meeting is held between Mosaic and the contractor management and supervisory teams," explains Alderdice. "On day one of the turnaround, a kick-off meeting is held that is attended by every contract employee to set the tone for the turnaround. Demonstrations are set up for safety focus areas specific to the activities for that particular turnaround or lessons learned from previous turnarounds. Then at least one member of the sulfuric area operations or maintenance staff attends each individual contractor's daily toolbox meeting to establish a safety contact point with every single contract employee every single day of the turnaround. The Mosaic safety team holds a daily meeting with all of the contractor's lead field supervisors and field safety supervisor (each contractor is required to provide its own field safety supervisor). The daily turnaround planning and coordination meeting includes all of the other contract foreman and begins with safety discussions that include review of all of the daily audits and observations to ensure that everyone is aware of all of the safety activities going on."

Emergency communications is another part of the safety planning. Contract field safety supervisors are provided with Mosaic plant radios and are required to have a system in place to notify all of their field foremen immediately with a single call or text in case of emergency. The final contact point takes place during the job safety walkthrough that takes place between the operations personnel and the crew performing each job as part of the standard safe work permitting procedures.

By integrating contractors into the process, New Wales is building important relationships. "Every contract employee out in the field knows they can bring up an issue, and we'll follow through," says Maintenance Supervisor Barry Brown. "Our goal is to avoid a reoccurrence of a significant near miss or incident. So if it takes an extra three days or an extra three weeks to get the job done safely, that's what we are going to do. Safety is number one."

The improved relationships have been earning dividends. "Now the contractors will come up to us and challenge us to examine their work, along with the work of other contractors and Mosaic employees, to see if we can find things that might cause incidents," says Brown. "It used to be they'd get nervous when we approached them. Now they want to talk to not only us about what they're doing, but to other contractors as well. This new culture has created an atmosphere where they all feel comfortable talking to each other about safety."

"You can actually feel it when you walk around the turnaround areas," agrees Alderdice. "Everybody is coordinating and communicating better, and looking out for each other as well."

And the results of all these efforts? Despite the New Wales sulfuric acid department executing some of the most complex and dangerous turnarounds in its history, there has not been a recordable injury during a turnaround since 2008. "That's 14 consecutive turnarounds without a single injury in any one of them," says Hagemo. "Of all that has been accomplished in these sulfuric plant turnarounds, this safety performance is what we all take the most pride in."

Operations staffing and training

With the investment in capital equipment and plans to continue extending operating cycles to 36-months and possibly beyond, the performance of the supervisors and operators who actually run the plants becomes even more critical. The standards required to operate three HRS units and maintain top performance of a sulfuric acid plant over a 36-month operating cycle without any hiccups are higher than ever before.

Recognizing that having the proper talent is crucial to the success of any operation, Phan's Continuous Improvement group was instrumental in getting additional headcount to do the work, but not before conducting a comprehensive analysis of plant roles and goals. "Our task was to really understand who's doing what and who needs to be doing what," says Phan. "So we interviewed a lot of people and asked a lot of very specific questions, like, 'What are your key performance indicators? How is success in your job measured? What are your goals? What's working well for you? What's not working well?'"

The analysis identified all the tasks necessary to achieve the plant's goals and when compared to the tasks that were currently being performed, there were many tasks left unassigned. The analysis also identified that the employees were performing their jobs very well, but there simply wasn't enough employees to complete all the tasks.

"It was the specificity of Ky's group being able to document all the roles and responsibilities that are needed to get us where we want to go, and identify all the standard work within those roles," explains Willis. "That became the blueprint that we used to compare against our existing staff. We were able to clearly show management exactly where our staffing fell short, and we got the additional headcount we needed," he says. "It's unusual to see headcount added," Willis continues, "but that's the leverage the CI group brings to the table—the ability to get the necessary support from the highest levels. And these days, Mosaic management has been following through and delivering the goods to us every time."

Another critical aspect that came out of the evaluation was a lack of consistency in the training of the operators. Each operator was performing his best, but sometimes assigned tasks were under-defined or incompletely understood. "These differences in understanding and performance levels," explains Sulfuric Acid Production Coordinator Rod Dexter, "were a result of inconsistent training practices within the department." So, based on standard work tasks and roles evaluations, a new training program was developed from the ground up. "And all of the operators went through it," Dexter recalls, "from those with 25 years of sulfuric experience to the ones who never set foot in the acid plant. And everyone came away with the exact same understanding of all of the roles and responsibilities of each operating position in the department, the same standard work definitions and exactly what performance levels were expected for each task."

The most beneficial portion of the new training program was the custom-designed computer simulation model of the New Wales sulfuric acid plants developed by MECS/DuPont. "The simulators have been invaluable not only in terms of abbreviating learning time," Willis explains, "but especially in terms of the confidence that the operators developed in their abilities because they have actually run the plant and troubleshot every possible failure scenario on the simulator. The simulator is essential training for the chief operators as it gives them the ability to learn and make mistakes on the simulator, whereas in the past these learning mistakes were made on the actual plants. The training supervisor works in the background and can input scenarios for every failure that has occurred in the 40-year history of New Wales," Willis says.

Production Coordinator David Sheffield worked with the MECS/DuPont development team to get every detail of the actual plant operations modeled. "The simulator ended up being so good," says Sheffield, "that I challenged any operator to take a double blind test whether they were operating the simulator or a real plant. So far, nobody has taken me up on it." The only complaint the operators have about transitioning from the simulator to the real plant is that they no longer have the simulator's pause button. "But when you get right down to it," Sheffield says, "there really isn't anything the plant can throw at them that they haven't already experienced on the simulator."

An additional benefit to the simulator is that field operators can use it to learn how a chief operator runs the plant. Understanding what the chiefs need from field operators improves the performance of the field operators as well as prepares them to develop into chief operators.

The training program has proved a resounding success—and in sharp contrast to the manner in which operators have historically learned their jobs. "The training we used to have was school of hard knocks—learn as you go," says Dexter, "but now our training process is world-class. We're taking guys who have never set foot in an acid plant before and turning them

The sulfuric acid process engineering team includes, from left, Theresa Rowe, Crystal Alonso and Superintendent Nicole Christiansen.

Plant Operations/Maintenance team members are, left to right, Drew Evans, Ricky Carlson, Keith Willis, Rod Dexter, Chris Thomas, Barry Brown, Doug Simmons and Keith Eldridge.

into chief operators in six months. In the past, an operator would have to be in the job for six years before you'd even consider making him chief."

Maintenance reliability

Mosaic has also been investing in other areas of New Wales' organizational structure to keep the facility running world-class. Maintenance reliability, maintenance workflow, plant automation, process control engineers and advanced process controls are all areas that have been supported to a degree never before seen at New Wales. The concept of staying ahead has been a major focus for the maintenance organization over the last several years. From a mainly reactive strategy, the work has shifted to a strongly proactive strategy. "We're finding issues before problems manifest," explains Chris Pearson, Facility Maintenance Manager. "We're finding issues earlier on the failure curve so we can address them sooner, quicker and more cost effectively."

Another significant piece of the philosophy is employing an asset management program for the plant. "Every piece of equipment will have a spare parts program, a cataloguing system for all the specifications, as well as a preventative and predictive maintenance program," Pearson says. Another significant piece of a good asset management strategy is spares management. "We are systematically reviewing typical failure modes of each of our existing assets to ensure we have the right spares cataloged, documented in the BOM and, where required, stocked in the store room," Pearson says. "With several major capital expansion project currently underway, it is important that we develop a spares management strategy long before commissioning the new assets."

The main goal of a proactive reliability model is to improve overall equipment effectiveness (OEE) to insure the assets are available to run whenever operations needs them to run and they are capable of running at full capacity.

The changes have been on a revolutionary scale. "It wasn't too many years ago that our maintenance strategies were mostly reactive. Now we have a staff of reliability experts who are dedicated to the development of proactive strategies for all major assets," said Pearson.

The field plant maintenance organization is also coming up to speed. "Our entire group, from planners, schedulers and supervisors, right down to the mechanics in the field, went for a week-long training on root-cause analysis, thinking about why something might fail, and even anticipating a failure so you can avoid it altogether," says Brown. "You never heard of sending mechanics to this type of training before. The old culture around here was operations ran it until it failed and then maintenance fixed it. We're not doing that anymore—with mechanics out in the field having the training they've had—we're staying way ahead of it now."

The improved reliability program has also benefited turnaround planning. "Maintaining comprehensive health analysis on all the equipment makes defining the turnaround scope much more precise," says Sisco. "We can identify, with specificity and hard data, what maintenance needs to be done and which pieces of equipment have outlived their usefulness." This specific data presented in a standardized format has been essential in securing the necessary funding to properly maintain the asset value of the New Wales sulfuric acid plants. "And getting the budget commitment to turnarounds early on," Sisco continues, "has allowed earlier turnaround planning, which was essential to the success of the complex acid plant turnarounds over the past five years."

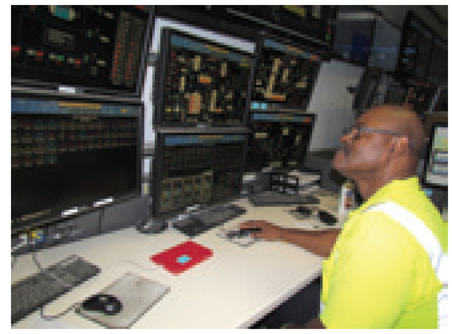
Opportunity capital projects—the "game changers"

With the capital equipment replacement program well under way and the operations and maintenance teams reorganized and focused on optimizing existing acid plant assets, Mosaic management turned its attention to identifying capital projects that could deliver improvements on a game changing scale. The opportunities targeted were energy recovery/power generation and raw material supply, the two areas of sulfuric acid operations that have the biggest impact on reducing operating costs and increasing revenue generation for the New Wales complex.

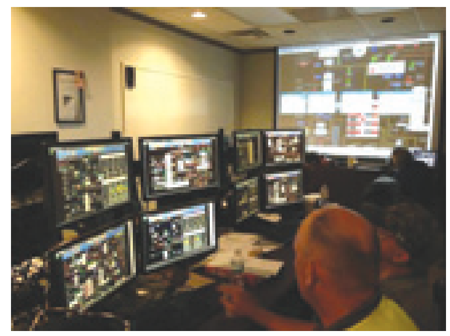
The first energy recovery and cogeneration project was completed in 2009. The scope included the addition of two heat exchangers into the existing acid plant systems and a new turbine-generator (TG). The two heat exchangers recover additional heat from the IPA circuit at the 02 plant and from the original HRS unit located in the 03 plant to pre-heat boiler feed water. The additional steam generated is used to drive a 30 MW generator that was relocated from a plant site that had been shut down in the early years of Mosaic and re-designed to fit the steam system at New Wales.

The next energy recovery opportunity was the retro-fit of two acid plants with MECS heat recovery systems (HRS) and the installation of a fourth turbine generator. This project was commissioned in the summer of 2014. The MECS HRS was

02 Plant HRS system with steam injection was commissioned in June 2014.



Chief plant operator Vance Governor at the 04 Plant DCS workstation in the New Wales central control room.

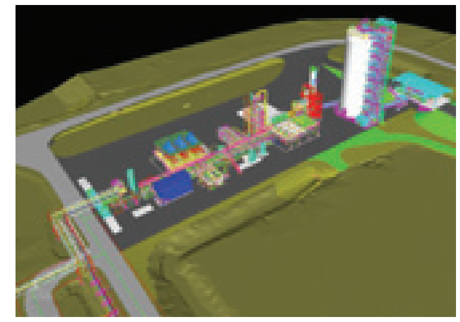


Production Coordinator David Sheffield demonstrates the process controls simulator developed by MECS/DuPont for the New Wales standard and HRS retrofitted acid plants.

Process Controls Specialist Chris Sutherland demonstrates the use of mobile technology for instrumentation system field maintenance.

ordered with the latest steam injection system design to generate even more steam than the traditional HRS design. "Putting steam into a gas system duct prior to an acid tower goes against everything operations has learned about running a sulfuric acid plant, but the system really performs." says Willis. "The steam injection controls automatically adjust to plant rate changes so it is almost as simple as just turning it on or off when you start up or shut down the acid plant." This 30 MW TG runs exclusively off of steam generated in the two HRS systems and gives New Wales the ability to not only supply its own 60 MW base load, but also supply the power requirements of Mosaic's largest mine processing plant and export power to the local utility company.

Installing all of this new capital equipment presented challenges not only in the coordination of the turnaround executions, but during the engineering design phases as well. "Given all the new equipment going in, the engineering design teams had to keep a close eye on how each new component would affect the entire acid plant



A 3-D model image of New Wales Sulfur Melter targeted to be operational by the end of 2015.

design," says New Wales Energy Project Manager Kristi Farrell. "With the many different engineering contractors, we had a lot of drawings that all had to mesh together. And because the energy project had such a great impact to the design, it just made sense to 3-D model the entire plant."

This 3-D modeling has made the designs much more understandable and easy for everyone to evaluate. "Trying to put a bunch of individual drawings together, it's really difficult to visualize how all the designs integrate as a system. But we can take the 3-D model and show it to the operations and maintenance folks and get their feedback on the spot," Farrell explains. 3-D modeling had been used for many years for individual equipment projects, but with the size of 2014 HRS project and the five sustaining capital projects happening at the same time, it was necessary to model the entire acid plant in order to ensure that all of the individual project designs integrated into the existing plant equipment. After these experiences, 3-D modeling has become the standard for all of the sulfuric acid plant projects. Because of their readability, the models have become broadly used across the plant to evaluate ergonomics, develop repair plans, maintenance planning and scheduling. Most importantly, operations can use them for equipment lockout planning and permitting, giving them the ability to show the work crew exactly the equipment location where they will be working and how the equipment has been prepared to be safely worked on.

The other game changing project is the installation of a sulfur melting facility at the New Wales site. "With Mosaic being the world's largest producer of phosphate fertilizers, it stands to reason that we are also the world's largest consumer of sulfur," says Director of Raw Materials Procurement Hermann Wittje. "We consume 4.5 million tons of sulfur annually in our process. That large volume leads to unique concerns about supply security for this essential raw material."

Sulfur used for fertilizer production generally comes in two forms, molten sulfur and prilled sulfur (reformed solid granules). Sulfur is a by-product of petroleum refineries and natural gas production facilities. With the advent of the new reserves of low-sulfur content shale gas and oil currently being mined in the United States, the North American sulfur supply is expected to progressively tighten. World supplies, however, are set to expand significantly. Most of the rest of the world's sulfur is traded in the solid prilled form. Mosaic has, in the past, predominantly used molten sulfur in its Florida phosphate operations. However, as the world sulfur markets change, Mosaic needs to tap into this expanding world supply of sulfur to assure cost efficiency and supply security.

"This project will enable Mosaic to use a combination of molten and prilled sulfur," Wittje continues, "and ensure an economical and reliable new supply source to fulfill our obligation to remain a low cost producer of phosphates for years to come."

In addition to the supply chain flexibility and commercial advantages that the melter will bring to Mosaic, the New Wales facility will now have a substantial portion of its sulfur coming through the melter, which comes with a filtration system. "Since our current sulfur supply comes from many varied sources, we have had little or no control of the quality of sulfur we receive," says Wittje. "Having direct control of the sulfur quality means opportunities to reduce the rate of catalyst bed fouling caused by impurities that come in with the sulfur. This will be critical to our efforts to extend the acid plant operating cycles to 36 months and beyond."

The project is already under construction and targeted to be operational prior to the end of 2015. "The sulfur melter will be the largest in the world when it is completed, but the facility design has been optimized for compactness, operational flexibility, as well as world-class safety and environmental considerations. By utilizing a modular approach, the project delivery method has also been tailored to meet business objectives as well as to minimize impact during construction on a site that is very active right now," explains Project Manager Thomas Dombroski.

Devco, a Tulsa, Oklahoma based engineering and construction firm, has been awarded a project for a turnkey sulfur melting plant – including sulfur truck unloading, storage and melting systems. The original project was to melt the sulfur at the Port of Tampa, but applying the continuous improvement principles and value stream mapping, it was determined that it was actually better to melt the sulfur at New Wales.

"New Wales already has steam and power available," explains Jim Gruber, Materials Handling Operations Manager, who will be running the new melter. "So there is a substantial reduction in the capital investment requirements not having to build a natural gas combustion unit and boiler to generate steam." Operating costs will also be lower because the electricity requirements will be provided by power that is generated from energy recovered from the sulfuric acid plants. "This is a big cost savings in comparison to purchasing power from the utility company. But best of all," Gruber continues, "there is zero environmental impact from the melter from a carbon footprint standpoint because the steam and electricity generated at the New Wales facility adds no CO_2 emissions."

The HRS system's teflon lined acid dilution vessel.

Moving into the digital age

Committed to continuously improving, New Wales has many other projects under development that will help ensure its world class operating status well into the future. One of the first areas being targeted is automation. Optimizing plant performance at New Wales entails keeping up with the technological advances available to the industry. Several years ago, New Wales upgraded the 1970s generation Digital Control System (DCS), but it ended up being greatly underutilized until a team of automation technicians were employed to focus on utilizing the new systems to their fullest extent.

"The plant was already automated," says Drew Evans, Electrical & Instrumentation (E&I) Supervisor, "but we had a lot of work making it perform well."

During the DCS modernization, the E&I group also combined the two old control rooms into a single location from which all five acid plants are run and also installed dual servers to the controls network to create the redundancy necessary for 100 percent uptime. Process Controls Specialist Chris Sutherland is currently completing the terminal server installations to allow the integration of mobile devices (iPads) to the control system networks.

"In addition to these terminal servers," explains Sutherland, "we are installing plant-wide industrial WiFi that will allow the new sulfur melter to be tied back in to the control network to increase operator productivity and flexibility. Ultimately security protocols will be developed that will allow integration into the Mosaic networks to provide remote monitoring of the controls system from mobile devices off the plant site as well as more integrated access to real-time management data, operating procedures and documents."

The new sulfur melter plant was designed and staffed based on the flexibility afforded to an operator from the integration of the traditional DCS systems with the latest mobile devices. The new facilities operators will be able to monitor and control their plant's operation from the mobile device out in the plant, looking at the same DCS screens they see in the control room. They can keep an eye on the equipment and watch the process changes made from their mobile device happen right before their eyes.

The high efficiency HRS designs at New Wales include a heater and pre-heater to recover additional energy from the high temperature acid and pre-heat HRS boiler feed water.

The maintenance reliability group will enjoy similar efficiencies as a pilot program using iPads gets underway. "This will be a paperless system," says Pearson, "where a mechanic can walk up to an asset, and, using his mobile device, input readings, record inspection results and even order parts for any necessary repairs that will be ready for him by the time he goes to the warehouse to pick them up."

New Wales' process engineering team is also driving improvements for the future. "These are exciting times for the process engineering team," says Process Engineering Superintendent Nicole Christiansen. "We are able to do a lot more than routine support with our active participation in commissioning and startup of the HRS and TGs. This type of participation provides great experiences for our team. We have been spending a lot of time in evaluating the best options for the National Ambient Air Quality Standard (NAAQS) and have also endeavored on energy optimization type projects with advanced process controls and improved steam balancing."

Process Engineer Crystal Alonso is working on another project that implements advanced process controls (APC) to help manage steam and power generation. "The APC system will be custom designed using "fuzzy logic" that actually teaches itself how to maximize steam and power generation from the data it collects monitoring the plants while they are in operation," Alonso explains. Initially the APC will be developed for the sulfuric acid plant and generators; then, once this base system is in place, it will be expanded to incorporate other areas of the fertilizer complex that impact power generation.

"The New Wales fertilizer complex uses one million pounds per hour of steam to evaporate and concentrate phosphoric acid for the manufacture of fertilizer," Alonso continues. "The expanded APC model will be used to maximize phosphoric acid concentration in the reactor, increase evaporator operating efficiencies and cleaning cycles, and manage acid tank farm inventories to balance out the instantaneous evaporator loading—all of this to maximize the amount of steam available for co-generation. The model will be further expanded to include fertilizer production planning since the different fertilizer products require different concentrations of phosphoric acid, which changes the steam demand on the evaporators. Ultimately, the mine processing plants, which rely on power generated at New Wales, will be included in the model to determine the best operating rates and outage schedules between the complexes—all with the goal of maximizing the power generation at New Wales."

To support the plant's existing automation team, Theresa Rowe is taking on a new role as Process Controls Engineer. "Initially we will start with the existing DCS process controls, clean up the alarm systems and tune up all of the control loops to make life easier for the plant operators," Rowe explains. "Then we'll move on to developing the higher level process control schemes to better operate all of the plant's systems and fully utilize the capabilities of the APC system that Crystal (Alonso) is working on."

The advancements in automation and process controls provide great contrast to the way things used to be at New Wales. "The first superintendent I worked for once told me about the original sulfuric acid plants built in the 1960s at Mosaic's South Pierce site," recalls Dougherty. "There were no automated controls at all, and the control panel consisted of motor run lights, start/stop buttons and a few chart recorders for the furnace and converter temperatures. The only process variable controlled from inside the control room was the acid dilution water. There was a water pipe that came through the back wall to a rotometer and a valve monitor to adjust the flow. Everything else was manual valves and gas dampers out in the field and hand written paper log sheets."

"By the time these new process controls, automation and APC projects are completed," Dougherty says, "the way we will operate the plants wouldn't even be recognizable to acid plant operators of past generations. And today's operators wouldn't be able to run the plants to the standards we expect without them."

Moving toward the future

With a strong belief in its future and a commitment to its goals, Mosaic's New Wales sulfuric acid team has accomplished more in the past five years than in the previous 20 years. At the core of this success has been a willingness to take a continuous-improvement approach, looking at every area of the business for ways to improve. No stone was left unturned. With each new improvement, the sulfuric acid plants provide an ever greater contribution to the New Wales bottom line and Mosaic's future success, and continue to maintain their world class status for the 21st century. ❑