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Trends in sulfuric acid: 25 years ago vs today

By: April Smith, Editor, Sulfuric Acid Today

Reviewing the past is useful for planning the future, so for *Sulfuric Acid Today's* 25-year anniversary, we wanted to take stock of the major changes in the industry over the last quarter century. We turned to the experts, those with the greatest experience in this business, many over 35 years. We surveyed consultants, product and service suppliers, and acid manufacturers about what they see as the predominant shifts from 25 years ago to today. Here are their answers.

Challenges for producers

Leaks

The most commonly cited challenge over the years has been leaky systems stemming from poor materials of construction, often cast iron, and the piecemeal manner of construction. The many cast iron sections bolted together resulted in lots of leaky seams, SO_2 emissions, and safety hazards. "There were acid coolers leaking at the seams and bio-foulants growing in the joints. Operators frequently had to go out with chipping hammers to remove the algae and scale from the coolers. And this was often done while the plant ran," (Feryl Masters, Consultant, Feryl Inc.).

Knowledge deficit

One of the most common issues in the industry today is the shrinking workforce, in numbers and experience. "Twenty-five years ago, most established companies had seasoned staff operating and managing the acid plants. Today, it is not unusual to have inexperienced staff operating the plants, including the supervisory and management positions," (George Wang, Consultant, GW Consulting Inc.).

Headcount reductions have caused "a knowledge vacuum," with the most senior people reaching retirement age, and too few replacements coming up the ranks. The push from investors wishing to boost financial performance has driven companies to reduce staff. "Deferring reinvestment in human resources causes some to leave the industry and also lowers the morale of those who remain," (Rick Davis, Consultant, Rick Davis and Associates).

Years ago industry suppliers would encounter well-versed owners. "We had clients with 20 or more years of experience not only showing us what to do but why to do it. They operated plants before the age of computers and truly understood how an acid plant worked including cause and effect. Those individuals are few and far between today," (Jack Harris, President, VIP International).

In addition, the growing population of inexperienced plant owners are choosing design and build contractors who are also inexperienced. "New producers expect that all bidding contractors have the necessary expertise to specify, design, and build plants, and so they just choose the lowest bid rather than have a thorough bid comparison." But many of the engineering and construction companies lack the hands-on acid plant experience to complete the job correctly, so these new producers suffer the consequences for years to come, (Wang).

Safety

Keeping people safe was a challenge 25 years ago that still persists today, but the industry's commitment to safety has evolved. "In the old days, the attitude at some facilities was 'we have a job to do. Be as safe as you can.' Today the attitude is 'if we are going to do this job, we are going to do it safely or we not going to do it,'" (Harris).

Though commitment to workforce safety has improved, today's experience gap has posed challenges to safety efforts. Companies today are performing more thorough safety reviews than in the past, but their quality depends on the available talent. "The resources and qualification of the review team is critical. If the team members lack hands-on acid plant experience and thorough understanding of the process, then the review may not be as effective," (Wang).

A bright light in the safety realm that respondents cited is the collaborative efforts by a cross-sectional group of industry experts who have been documenting and sharing hydrogen safety information.

Stricter standards

Another significant challenge facing the industry today is the preponderance of ever stricter standards and goals that producers must meet. Plants today are striving for substantially more stringent environmental, governmental, and financial goals. Achieving these goals, in turn, involves greater measurement, reporting, and oversight activities.

Most impactful technological advancement

Materials materials materials

By far the consensus advancement over the past quarter century is the increased acid resistance of construction materials. "High alloy steels and a variety of corrosion resistant plastics are the main improvements," (Gavin Floyd, Engineering Manager, Eco Services).

Twenty-five years ago most plants used lead, cast iron, and red shale bricks. "The philosophy was to design with a large amount of corrosion allowance. But this meant heavy weights, low flexibility and, in the case of lead in wet gas cleaning systems, materials that were too soft and toxic," (Mike Fenton, Senior Business Development Manager, Chemetics, Inc.)

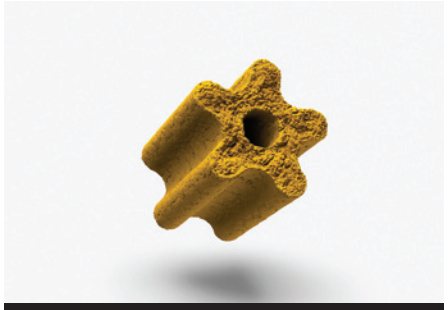
The variety of better materials enabled equipment designers to select the most suitable material for the specific application. For example:

- Stainless steel for converters, towers, heat exchangers
- Anodically protected stainless steel for acid coolers
- Nickel-based alloys for piping and acid tower replacement projects
- Ductile iron alloy (Mondi) for piping
- Composite materials and advanced alloys for WESPs
- High silicon alloys for piping, ducting, vessels, heat exchangers
- Fiber reinforced polymer (FRP) for gas cleaning ducting, piping, dampers, etc.

The longevity and efficiencies of today's materials is irrefutable. "Advancements in materials have allowed plants to run at lower risk, higher temperatures, for longer times between outages, and at greater capacity," (Charlie Fast, Reliability Lead, Mosaic Co.).

Catalyst

Another major advancement during this period is the change in catalyst shape, from pellet to an optimized multi-surface design, which reduces pressure drop and extends plant run time. Catalyst pressure drop was the primary reason for acid plant turnarounds, when plants had to shut down to screen catalyst to remove dust and debris.



The many contours of Haldor Topsoe's LEAP5™ catalyst is a major design advancement over the simple pellet shape of the past. LEAP5™ is specifically designed for oxidizing SO_3-strong gases.

Better catalyst combined with improved handling techniques have significantly extended turnaround cycles, which has had profound industry effects. While greatly improving plant performance, better catalyst and handling presents a new set of challenges. Comprehensive maintenance planning and inspections are now required to ensure all equipment is reliable for the longer two- or three-year run without any unscheduled outage (Harris).

Catalyst also impacts SO_2 conversion and so was subject to the pressures of environmental regulation. Developments in cesium-promoted catalyst have greatly improved SO_2 to SO_3 conversion and reduced SO_2 emissions," (Guy Cooper, Director, NORAM Engineering and Constructors Ltd.).

New software technology also came into play to better understand catalyst chemistry, which helped advance design. "New formulations and shape, such as Haldor Topsoe's LEAP5™ and MECS' GEAR®, further reduced catalyst pressure drop and improved conversion efficiency. Today's double absorption plant can achieve 99.9 percent SO_2 conversion or higher," (Wang).

Heat recovery

Today's heat recovery technologies have increased the benefits of cogeneration. Before 1980 nearly all of the heat generated in the acid system was lost to the cooling water system. With current heat

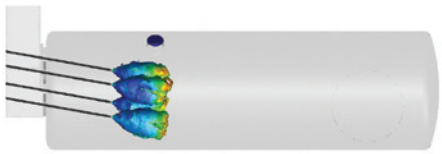
recovery systems, more of this heat energy is captured, significantly increasing the plant economics. "Today's HRS technology can achieve 900 psig and 900 degree steam systems, whereas before 1970, most plants had less than 600 psig and temperatures below 600 degrees," (Davis).

"For plants to be able to boost and then harness their own energy, for example by using MECS® Heat Recovery System (HRS) technology, producers can both increase plant efficiency and materially reduce their carbon footprint," (Brian K. Blair, Global Licensing Manager, DuPont Clean Technologies).

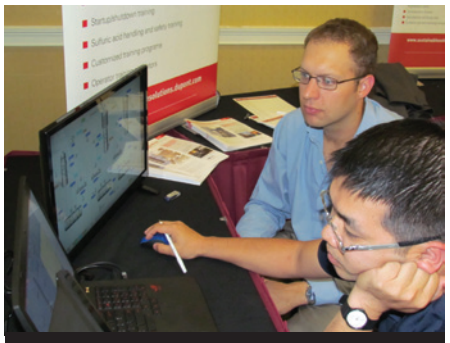
Modeling and measurement

With the advancement of the digital age, tools that simulate and measure the acid environment have become part of the process. Respondents identified a few they felt were particularly notable:

Emission analyzers: Testing how much SO_2 a plant emits can now be accomplished with in-stack analyzers, which provide immediate, precise measurements. This contrasts with the complicated, time consuming, and imprecise Reich test of the old days, (Masters).



Computational Fluid Dynamics (CFD) modeling software allows suppliers to truly understand the physics and chemistry inside the burners/furnaces so they can develop solutions to increase plant performance.



Simulators that most authentically mimic actual plant dynamics are especially valuable, particularly as more plants experience higher retirement levels and knowledge deficits. Brian Lamb of MECS monitors an operator simulator challenge at a MECS SAR Technology Workshop.

Modeling tools: Computational Fluid Dynamics (CFD) modeling software allows suppliers to truly understand the physics and chemistry inside the burners/furnaces so they can develop solutions to increase plant performance. CBA WhirlJet and Injector is such an example, (Christy Hofherr, Director, Spraying Systems, Co.).

Operator process simulator training: Simulators that most authentically mimic actual plant dynamics are especially valuable, particularly as more plants experience higher retirement levels and knowledge deficits, (Thomas L. Muller, Engineering Fellow, Veolia North America).

Environment: trends, challenges

It's part of business

The last two and half decades have crystalized the notion that environmental stewardship is an indelible aspect of a viable operation. "For a plant to maintain its License to Operate, it must meet its emissions, all other environmental targets, plus safety obligations or it's only a matter of time before the community or the government will call for it to be shut down," (Herbert Lee, Sulfuric Acid Sales Manager, Chemetics).

$S0_2$

Whether it's 25 years ago or today, producers have been wrangling with this pollutant, the difference being the acceptable limits. The challenge has been making sufficient and economically feasible plant modifications to reduce the formerly allowable 4 lbs/ton emission level to the current 1-2 lbs/ton.

"Government regulations, as well as financing institutions such as the World Bank, continue to push producers to reduce stack as well as fugitive emissions every day, all day." Though compliant plants have been built in the chemical and smelter industries since the 1980s, more and more producers in the fertilizer space are being held to the same standard. Additionally, the need is expanding abroad, becoming necessary in India, China, North Africa, and South America, (Fenton).

Over the last two and a half decades the most impactful technologies to mitigate SO_2 have been double absorption, low ignition catalyst, and SO_2 alkali scrubbers, (Leonard Friedman, Consultant, Acid Engineering & Consulting Inc.). "As a result, single absorption acid plants without scrubbing have virtually disappeared in the United States," (Cooper).

Industry suppliers have developed a variety of abatement products and services to address SO_2 emissions throughout the production process. Some of their solutions are as follows:

Acid Piping Technology offers improved stem packing of damper valves used throughout gas ducting. "The stuffing box design impedes internal gas from flowing into high pressure areas and ultimately escaping into the atmosphere," (Ed Knoll, President, Acid Piping Technology).

Chemetics offers full-process acid plant designs using proprietary equipment to achieve required stack emissions in any weather condition and at varying operational rates, (Lee).

DuPont Clean Technologies offers MECS® DynaWave® Wet Scrubbing Technology as a Claus tail gas treatment unit supplement or as a stand-alone unit for small-capacity plants. Also DuPont's catalyst & Brink® mist products help meet stringent compliance thresholds (Blair).

NORAM offers a process strategy for reducing start-up emissions for clients having more than one acid plant in which tail gas from the start-up plant is fed to the front end of the operating acid plant, (Cooper).

Outotec's Peracidox tail gas scrubbing system processes post acid plant SO_2 before the stack, for start-up and upset conditions (Hannes Storch, VP Metals and Chemical Processing Business Line, Outotec).

More focused attention on NOx mitigation in recent years has had a significant impact on sulfuric acid production. VIP International's "no-NOx" scrubber neutralizes an economizer at Eco Services' Hammond, Ind., facility.

Chemetics offers a unique NOx abatement technology, Selective Catalytic Conversion (SCR), to reduce emissions in traditional dry gas sulfuric acid plants. The method can reduce incoming NOx emissions by 95 percent.

Beltran's WESPs remove particulates and acid mist with collection efficiencies of submicron particulate matter at 99.9 percent or greater.

With stricter environmental regulations Outotec offers a gas cleaning plant solution that takes into account the complete process chain.

NOx, etc.

Twenty-five years ago NOx was not on the radar as a toxic substance in the sulfuric acid industry and the only way to measure it, using pumps with colorimetric tubes, was not very accurate. "As awareness of NOx increased, manufacturers developed atmospheric monitors with electrochemical sensors that accurately measure the components of NOx," (Darwin Passman, Safety Director, VIP International).

More recently, attention to NOx, acid mist, and other contaminants have increased and their mitigation has had a significant impact on sulfuric acid production. Industry suppliers have responded by developing a number of viable solutions. A few of the more prominent technologies are as follows:

Chemetics offers a unique NOx abatement technology, Selective Catalytic Conversion (SCR), to reduce emissions in traditional dry gas sulfuric acid plants. The method can reduce incoming NOx emissions by 95 percent, (Fenton).

Beltran's WESPs remove particulates and acid mist with collection efficiencies of submicron particulate matter at 99.9 percent or greater. The technology can also be customized to reduce heavy metal contaminants in sulfuric acid. "For example, recently a number of metallurgical acid plant WESPs have been sized based on the outlet arsenic requirements instead of the acid mist outlet loadings," (Michael Beltran, President, Beltran Technologies).

Outotec can offer NOx solutions throughout much of its technology portfolio, once legislation demands it. The company also has a wide technology portfolio for removing heavy metal contaminants from the off-gas stream. These products include WESPs, the industry benchmark process for mercury removal, as well as other niche solutions, (Storch).

Operations

Knowledge deficit

As mentioned earlier, expertise retiring without equivalent knowledge in a younger workforce has negatively impacted plant operations in recent years. "In the past, after we designed and built a plant, an experienced producer took it over. He knew what he was doing. This certainly is not the case today and is particularly problematic in remote areas with limited skills available in the local community," (Storch).

Remote monitoring, control

The digital age and the advancement of instrumentation, most notably distributive control systems (DCS), represent the most prominent operational innovation respondents cited over the last 25 years. DCS enables producers to see how a plant is running in real time as well as view an operational history to understand failures so that they can be avoided in the future. "DCS allows operators and engineers to look at trends with an ease that would have been considered magic in 'the good ole days,'" (Muller).

"Just the ability to share information electronically has been impactful to the industry because large groups of people, whether on- or off-site, can easily look at a problem and come up with better solutions and designs," (Floyd).

Maintenance issues, advancements

Leaks, corrosion

Unsurprisingly, the predominant maintenance concern historically for the industry was excessive localized corrosion and the leaks that resulted. "Twenty-five years ago it was common to have staff regularly walking around the plant fixing leaks." These days, as mentioned previously, corrosion is better managed with better equipment design and improved materials of construction, (Fenton).

Pressure drop

Pressure drop was also much more common 25 years ago and particularly damaging to an operation if it required a plant shutdown to address. "Today, improved catalyst and mist eliminators have made great progress managing this issue and extending turnaround time," (Blair).

Sulfur gun plugging

Plugged nozzles and resulting poor atomization and furnace/burner performance have persisted for 25 years or longer. Although the industry has gained traction here, "these issues still represent a primary concern for producers," (Chuck Munro, Refinery Application Specialist, Spraying Systems Co.).

Maintenance planning programs

Twenty-five years ago, maintenance planning was much more rudimentary. "It largely entailed keeping the right spare parts on hand," (Blair). And "equipment records were kept in someone's filing cabinet," (Davis). Today, records are digital and the emphasis is on predictive maintenance so that unexpected shutdowns do not occur.

Planning today is much more formalized. "Acid plants in the forefront of maintenance planning today practice Total Productive Maintenance (TPM), Reliability Centered Maintenance (RCM), or both," (Wang):

TPM uses preventive, predictive, and proactive maintenance strategies to maximize equipment efficiency. It also fosters teamwork throughout the organization, emphasizing empowering operators to help maintain their equipment.

RCM uses the most effective maintenance approach, employing preventive, predictive, proactive, and reactive techniques in an integrated manner to increase the operational efficiency of equipment within its design life cycle with minimal maintenance.

Acid Piping Technology's Mondi™ piping's corrosion allowance withstands weak acid excursions, thus reducing the potential for hydrogen events.

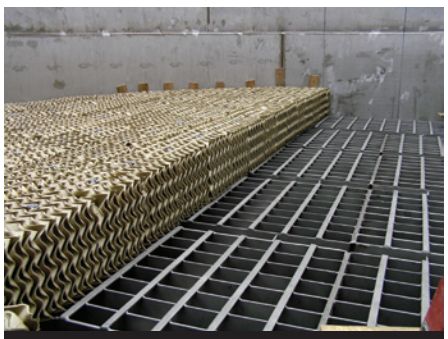
Materials

Predictably, the most impactful advancement to the industry overall plays a large role in easing the burdens of maintenance. Though stainless steel, alloys, and the like were available 25 years ago, their use has broadened as their benefits become better realized. In the past, the industry evaluated these better materials only by their higher cost. "Today, there is the environmental ethic that says leaks are unacceptable and that improved performance with better materials, though more expensive, is ultimately good for business," (Muller).

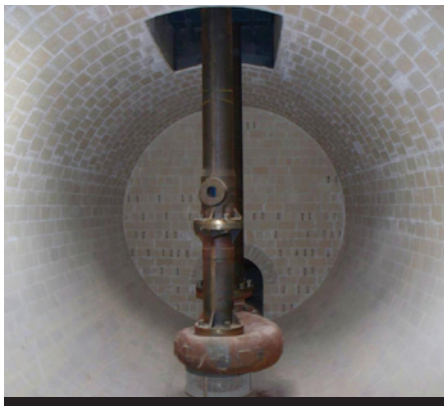
Better equipment and designs

Innovations in equipment design have contributed significantly to managing common maintenance issues of corrosion and pressure drop, and others. Some examples of equipment advancements industry suppliers have developed include:

Mercad's larger diameter main cathodes for use in anodically protected acid coolers save producers maintenance time because they can be cleaned easily and their longer life means fewer replacements.



Koch Knight's FLEXERAMIC® ceramic structured packing lowers pressure drop, is subject to less settling and sulfur buildup, lasts longer, and lowers power consumption.



Customized configurations of Lewis® pumps, like this one made from specialty Lewis® alloys, is a solution Weir Minerals offers producers with persistent weak acid corrosion in pump tanks. Lewis® proprietary alloy materials are designed to handle hot concentrated acid and oleum, and provide a long service life.

Acid cooler cathodes: Mercad's larger diameter main cathode for use in anodically protected acid coolers save producers maintenance time because they can be cleaned easily and their longer life means fewer replacements, (Barry Krentz, President, Mercad Equipment, Inc.).

Acid distributors: The design of Chemetics ISO-FLOW™ Acid Distributor with SWIFTLOCK™ uses so few nuts and bolts hardware that plant personnel can quickly assemble/dissemble the unit in the tower as needed," (Lee).

Acid pumps: For persistent weak acid corrosion in pump tanks, Weir Minerals offers customized configurations of Lewis® pumps made from alternative alloy materials, (Mick Cooke, Director of Sales and Marketing, Weir Minerals Lewis Pumps).

Acid tower packing: Koch Knight's FLEXERAMIC® ceramic structured packing lowers pressure drop, is subject to less settling and sulfur buildup, lasts longer, and lowers power consumption, (Douglas Popek, Sales Manager-Carolinas, Koch Knight).

Catalyst: Pressure drop issues have been reduced through catalysts with improved hardness and shape, (Blair).

Cold exchangers: NORAM's cold exchanger with a hot sweep helps prevent condensation/fouling at the cold end of the exchanger. Design and fabrication techniques for ducting and expansion joints promote longer life, (Cooper).

Mist eliminators: A wide variety

of corrosion-related issues have been addressed by reducing the amount of mist carry-over through improved performance of MECS® Brink® mist eliminators, (Blair).

Mondi piping: Distribution systems and thick-wall construction withstands rapid corrosion from weak acid excursions, (Knoll).

Sulfur guns: The improved design of Spraying System's CBA WhirlJet and Gun minimizes plugging, translating to easier maintenance for producers, (Bandish Patel, Project Engineer, Spraying Systems Co.).

Expert contractors

Survey respondents cited contractors who specialize in servicing sulfuric acid equipment as a growing segment of the acid industry in the last 25 years, and one that producers have come to rely on.

"One of the most significant changes is the business relationship between the sulfuric acid producer and the service contractor. 25 years ago the contractor was seen as an outside entity and many times merely an expendable labor force, a necessary evil required to execute tasks the producer was unwilling or unable to complete with plant personnel. As one old, crusty maintenance manager told me, 'Son, you have to realize you have two strikes against you when you come through the gate because you're a contractor. If you were worth your salt you would be working at a plant like we are.' Today this attitude is replaced with one of cooperation and partnership, which has transformed an adversarial role into one of mutual success. Long-term relationships are fostered by building on experiences from the past and vision for the future," (Harris).

"Employing sulfuric acid maintenance contractors, such as VIP International, to work in acid towers, mist eliminators, converters, and heat exchangers, has had the biggest impact on maintenance for us. They have the know-how to get the job done correctly and safely, often in a very dangerous and nasty environment," (Carl Yamada, Consultant, Eco Services).

The lack of sufficiently knowledgeable maintenance staff on site in recent years had prompted industry suppliers to become experts in their customers' processes, and to develop services to keep customer plants up and running.

"We have expanded our service business to support the industry challenges and the new breed of customers/producers. Over the past ten years we have therefore gained significantly more intimate knowledge of how our plants are operating. This shift in our business even enables us to offer guarantees on plant availability," (Storch).

MECS® sulfuric acid plant equipment made with the ZeCor® alloy delivers superior corrosion resistance in a wide range of sulfuric acid concentrations, temperatures, and applications.

Turnarounds

Extension of TA cycle, shorter durations

A significant trend in recent years, and one that has become critical to site profitability, is the push to increase the duration between turnarounds (Fenton). Many producers are running two- to three-year cycles, or longer. Producers also look to minimize their TA schedules so they can resume production more quickly. Achieving these ends requires more complex planning and monitoring of equipment maintenance trends to avoid unplanned surprises that can extend the outage and increase costs, (Davis).

Better materials, designs

Utilizing stronger, lighter materials and more efficient equipment designs have played a large role in reducing turnaround durations and extending cycles. These are some of the products industry suppliers have developed to help meet those goals:

Acid towers: Non-bricked high silicon alloy NORAM SX™ acid towers can be assembled offsite and easily placed in the final location using a standard crane, (Cooper).

Converters: NORAM converters with enhanced ducting design allow simultaneous warming of two to four beds for quicker start-up, (Cooper).

Drying and absorption vessels: Acid Piping Technology's open spiral shaped tower packing design for drying and absorption vessels prevents fouling and plugging, which reduce pressure drop and repacking frequency. Long-term pressure drop performance exceeds conventional packing, (Knoll).

Drying towers: MECS' drying tower made of lightweight ZeCor® alloy can be assembled offsite and easily placed in its final location with a standard crane, (Blair).

Modular designs: Chemetics' modular equipment minimizes site work to accommodate abbreviated TA schedules. The designs also enable simple retrofit of large capital equipment like converters, acid towers, and gas-gas heat exchangers onto existing or new foundations to minimize shutdown timing, (Lee).

WESPs: Beltran's modern WESPs use advanced materials and electronics, making them more compact and easily installed without the whole system having to be shut down, (Beltran).

TA contractors

The same workforce reduction trends affecting plant maintenance have impacted turnaround work. Downsizing of plant maintenance personnel has increased the need for outside maintenance contractors; and contractors are becoming increasingly versed in site and acid industry specifics. Some examples include:

Chemetics optimizes turnaround plans to suit the client's site, taking into account the available space, local contractor skill set, site safety rules, and shutdown duration, (Lee).

DuPont Clean Technologies can respond quickly to unforeseen turnaround needs, including stocking catalyst at key locations, offering emergency Brink® mist cartridge repacking services, and supplying other process-critical equipment. Technical experts are also available to respond to urgent requests. Other service offerings include catalyst performance analysis via PeGASyS, fiber analysis for mist eliminators, and the Brink® stick test app, (Blair).

DuPont Clean Technologies, in coordination with Koch Knight, can quickly service MECS acid towers with Koch Knight's Type 88 FLEXERAMIC ceramic structured packing. "Koch Knight's inventory levels allow companies, such as DuPont Clean Technologies, to service customers more rapidly for critical equipment changeouts," (John Horne, DuPont Clean Technologies, MECS® Sulfuric Acid & Environmental Technologies).

Outotec begins its support of customers twelve months before a major shutdown to plan and schedule the turnaround, (Storch).

Better records, planning

The use of digital record keeping and planning tools has seen major growth over the last 25 years. Good scheduling tools have enabled shorter outages while maintaining safety and cost goals. For example, computerized maintenance management systems (CMMS) allow accurate sorting and planning for the long term issues that have to be addressed during TA periods (Fast). Even commonplace tools like MS Project help sites optimize resources more effectively (Floyd) and digital photographs captured during inspections simplify equipment histories, (Wang).

Safety

Twenty-five years ago, safety and health centered around workers compensation insurance and accident reports. "Then industry leaders began to see the toll taken on the workforce and the bottom line, and sought to reverse the negative trends," (Passman).

Today safety is seen as an integral part of doing business, even from an economical perspective. "A plant makes money only when it runs safely, reliably, and within emissions requirements. Every safety event, just like every leak or emissions issue, causes a plant shutdown. It is more cost efficient to spend a few extra dollars, about 5 percent more, to build a safe and reliable plant versus a minimum-cost plant. One unplanned three-day shutdown comes to roughly the same cost as the difference between the quality and low-cost plant," (Fenton).

"The difference between then and now is that instead of viewing safety as an expense, management now believes a safe plant can also be an efficient plant," (Davis).

"We have zero tolerance for incidents. Being just good was not where we wanted to be. People still were getting hurt. Now with the goal of zero, we actively work to find all the potential hazards and work them out of our processes," (Fast).

Knowledge deficit

As with other areas of sulfuric acid production, workplace safety has been affected by dwindling numbers of experienced staff. "Today there is a real safety impact to gaps in workforce knowledge, skill, and experience," (Wang).

Many companies recognize this knowledge gap and are looking to enhance their safety systems through training and coaching. "Studies into critical facets

of workplace safety have gathered large amounts of data that have been used to bring about new strategies in company initiatives. Stringent regulations by governments and a new thought process regarding the safety of workers have initiated changes in the area of safety that are continuing to evolve today," (Passman).

Safety programs

More facilities are voluntarily incorporating safety management programs into the workplace, and formal management tools like PSM (process safety management) and RMP (risk management plan) have had a significant impact. These tools enable teams to understand the effects each facet of an operation has on safety and organize efforts in a way that brings focus to each facet and shares safety responsibility across the entire organization, (Ron Cloud, Consultant, RDC Enterprises LLC).

"Companies implementing these programs properly have been realizing significant benefits in productivity, safety performance, and reduced costs for maintenance, operation, capital expense, and insurance," (Wang).

Prior to implementing the safety program at Eco Services, "we experienced explosions of electrostatic precipitators, tank fires, major SOx excursions, major boiler failures, etc," (Yamada).

Working in a potential NOx environment has its own protocol involving a precise sequence. This requires training, experience, and the equipment to safely enter and work in an Immediately Dangerous to Life and Health (IDLH) atmosphere, (Passman).

Safer equipment

In response to the call for safer working conditions in acid plants, industry suppliers have incorporated various features in their equipment designs. For example:

Chemetics designs its equipment and plants to provide feedback on plant operating conditions and prevent a runaway weak acid corrosion event. Anodically protected acid coolers automatically warn clients of an acid cooler leak, (Lee).

DuPont Clean Technologies plant and equipment designs enable maintenance activities to be accomplished in both a less invasive and more ergonomically correct manner, (Blair).

Mondi piping's corrosion allowance withstands weak acid excursions, thus reducing the potential for hydrogen events, (Knoll).

NORAM's Smart™ acid distributor has clean-out ports at the ends of each acid distribution arm so any collected chips can be removed from outside the tower, thus avoiding tower entry.

NORAM's acid tower designs place the exit duct on the top head to prevent potential accumulation of hydrogen that could occur with a side exit. NORAM's Smart™ acid distributor has clean-out ports at the ends of each acid distribution arm so any collected chips can be removed from outside the tower, thus avoiding tower entry (Cooper).

Some safety devices/instrumentation have experienced failures, causing unanticipated mishaps. "This topic is seldom addressed but it happens all the time," (Wang). Wang cites these examples:

Failures of combustion safeguard/management system causing a spent acid precipitator fire or explosion around the preheater/converter area.

Failures of O_2/ SO_2 analyzer measuring high stack SO_2.

Failures of acid concentration analyzer measuring high stack opacity.

Information sharing

Respondents noted greater levels of collaboration within the industry around safety issues over the last 25 years.

Safety training in Confined Space Entry procedures, Hazards Materials Handling, the proper use of PPE, and eliminating the use of asbestos materials are more common (Egan Godfredsen, Plant Superintendent, Border Chemical Co.).

Situations regarding hazardous incidents are being openly and more commonly discussed at industry forums. Some examples are:

A hydrogen safety workgroup comprised of industry designers, operators, and process consultants has been collaborating in recent years to study the causes and prevention of hydrogen incidents. The group has shared its findings industry-wide in an effort to improve plant safety (Storch).

Sulfuric acid workshops offer producers and suppliers from around the world the opportunity to share technology, experiences, and mishaps in the acid industry. George Wang, center, shares his experience with participants of the 2010 Australasia Sulfuric Acid Workshop in Sydney, Australia.

Sulfuric acid workshops offer producers and suppliers the opportunity to share technology, experiences, and mishaps in the acid industry around the world. Safety topics have been increasingly brought out in these workshops, (Wang).

"Conferences around the world allow a free exchange of information, ideas, and best practices to be shared throughout the industry. *Sulfuric Acid Today* has without a doubt had the largest effect on this exchange of information and ideas. Congratulations to Kathy Hayward on an excellent job and I wish her another 25 years of success," (Harris).

Training

Plant simulation training is the predominant training advancement respondents cited. Operators can experience mock plant failure events and practice responding to them. "Simulators that most authentically model the actual plant are most useful, as well as those that interface with the DCS the operators will ultimately use," (Muller).

"I've used a simulator for training brand new operators for two new acid plants. I would not want to start a new plant without one. While still relatively expensive and not in widespread use, I'll be surprised if they do not become a standard training tool in the near future," (Muller).

"It is also valuable to configure sulfuric acid training classes that cover both theory and practice, and that include the participation of seasoned operators and maintenance personnel to ensure the knowledge transfer to younger staff," (Yamada).

Future

Respondents had these thoughts on what the future of the sulfuric acid industry might look like.

Predictions

Plants getting larger and SO_2 emissions limits below 10 PPMV, (Leonard Friedman, Consultant, Acid Engineering & Consulting Inc.).

Materials improvements to minimize leaks in acid and gas, (Friedman).

Computerized control of electric power/efficiency, (Davis).

Artificial intelligence taking a greater role in process control and safety systems, (Davis).

Emphasis on mitigating greenhouse gases and pollution levels globally, which will level the playing field and drive further innovations, (Cloud).

Hopes

An industry-wide database of incidents, created by and for the industry, that includes equipment and instrument failures. This could be located on the *Sulfuric Acid Today* website, (Wang).

Corporate reinvestment into human and plant resources to address decades of little investment, the growing knowledge gap, and aging plant infrastructure, (Davis).

Compulsory and continuous training at all levels of the organization should be a core principle to have a sustainable operation. Technology is good, but in-house staff with detailed working knowledge of the operation, equipment, and failure modes of each component is critical, (Cloud).

A recognition among the next generation of acid plant engineers and maintenance workers that a career in the industry is challenging yet rewarding, (Floyd).

We hope this retrospective has helped illustrate how far the industry has come and helps you consider where to take it over the next 25 years. In the words of one survey respondent:

"There are many opportunities for improvement and technological advances waiting to be conquered," (Floyd). ❑