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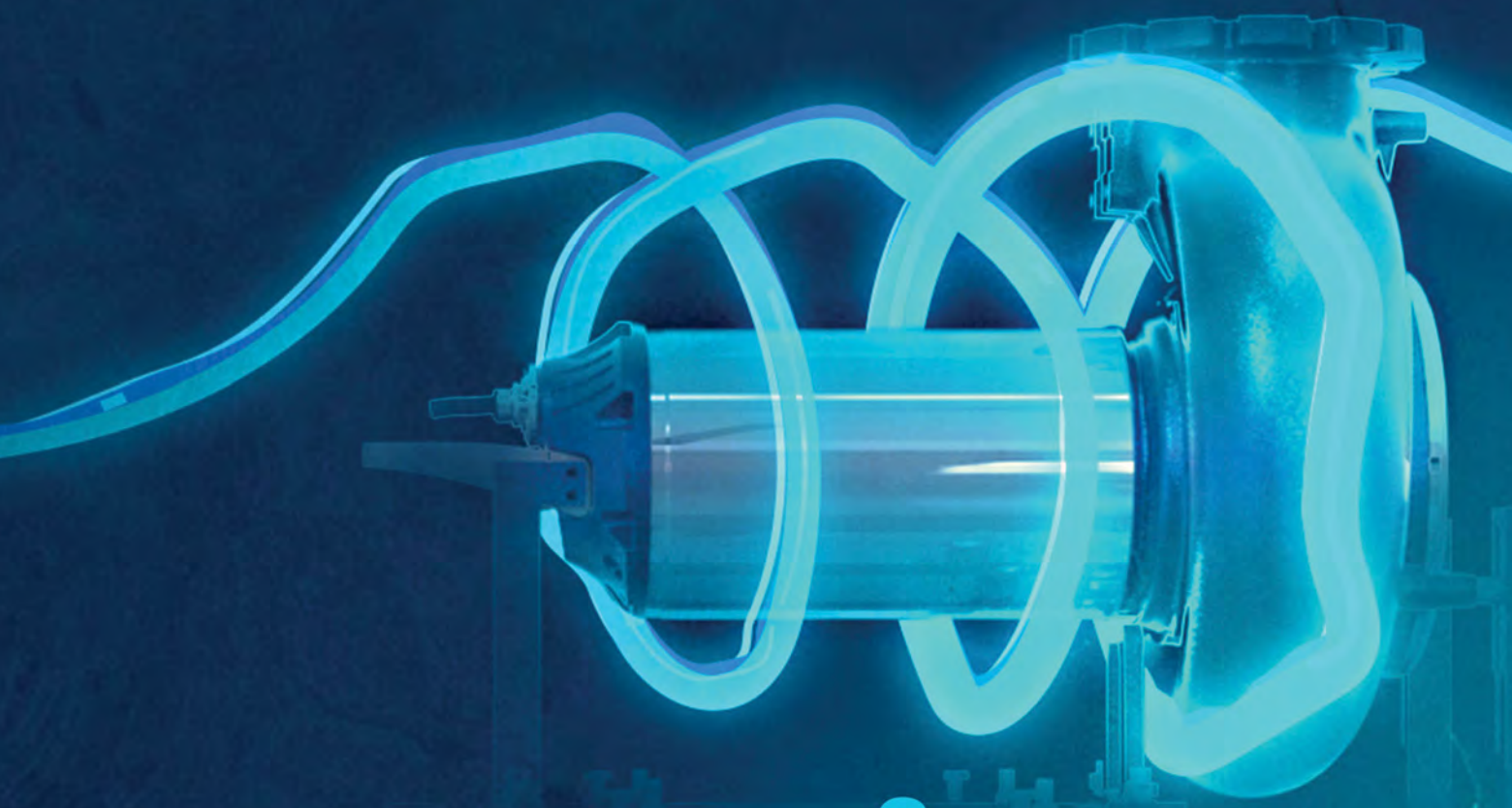

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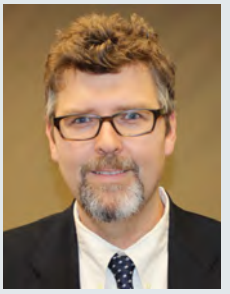

J. Campbell, Editor
Modern Pumping Today

Welcome to the July issue of MPT! Sewage spills can detract from the appeal of any community, and frequent MPT contributor Thomas Renner provides a look at the particularly problematic issues that faced Sarasota, Florida, in this month's Case Studies section (pg. 12). Find out how a creative lift station plan provided the solution.

As more baby boomers continue to retire in 2021, 62 percent of companies struggle to fill critical, skilled technical trade positions. Plus, the Department of Labor estimates 31 million skilled technical trade positions will be vacant by the end of year. In this month's Pump Solutions section (pg. 22), Sulzer's David Fasnacht offers ideas on how the pump industry can prepare for the brain drain.

Lastly, reliability analytics company Pinnacle recently released its second Global Economics of Reliability Report, which analyzes the impact reliability has on the water and wastewater treatment industry. Jeff Krimmel, Pinnacle's director of data and market analysis, shares the details in this month's episode of The Efficiency Point (pg. 36). Enjoy!

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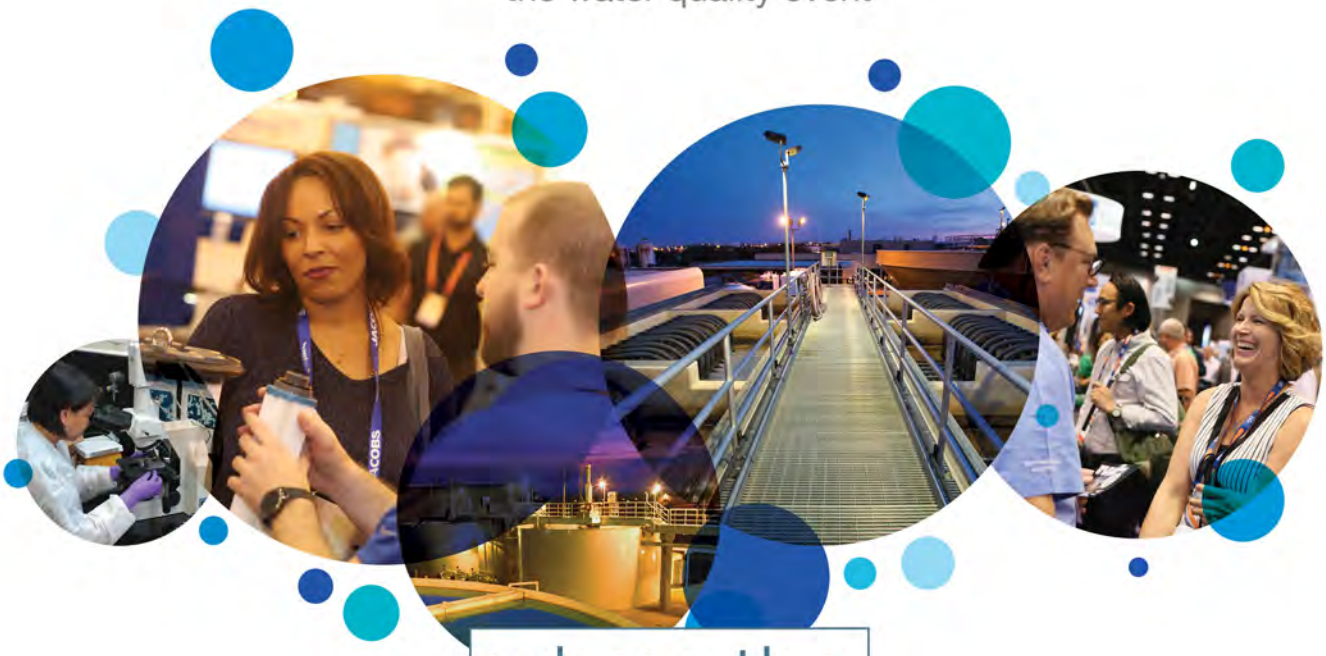

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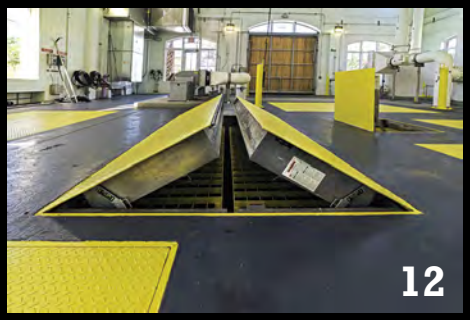

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SEEQ AND AMAZON WEB SERVICES PARTNER TO LAUNCH OF SaaS MIGRATION PROGRAM

Seeq Corporation announces the launch of a new program, the Seeq SaaS Workshop. In collaboration with Amazon Web Services (AWS), the Seeq SaaS Workshop simplifies the migration path to the cloud for Seeq's on premise customers. Seeq SaaS on AWS benefits for manufacturing organizations include ease of deployment, added support, and faster access to new Seeq capabilities.

Eligible customers participating in the Seeq SaaS Workshop will benefit from a no-cost SaaS migration service, along with additional pricing options for Seeq subscriptions. In addition, Seeq's dedicated support team will assist in efficiently migrating on premise Seeq implementations, data connections, and workloads to the AWS cloud.

Seeq's rapid growth is being fueled in part by its commitment to cloud-based computing. Seeq is available on AWS Marketplace, has AWS Industrial Competency status, and supports many data storage services, including Amazon Redshift, Amazon S3, plus machine learning in Amazon SageMaker, and other services.

"Customers go to AWS Marketplace to find solutions that provide advanced analytics and real-time collaboration to support their journey to the cloud," says Mona Chadha, director, AWS Marketplace Category Management.

GWS TOOL GROUP ACQUIRES INDEXABLE CUTTING TOOLS OF CANADA

GWS Tool Group has acquired Indexable Cutting Tools, Inc., the third acquisition in 2021 for GWS Tool Group and the first international acquisition by the U.S.-based manufacturer. Located in Welland, Ontario, and Edmonton, Alberta, Canada, Indexable is a technology leader in the manufacturing and distribution of ceramic, PCD, and CBN inserts. For more than fifty years, mastery of insert production and precision cutting technology has provided manufacturers around the world with an edge in operational efficiency.

The company supports an array of manufacturing companies with its products. From automotive and powertrain customers to commercial and defense aerospace manufacturers, Indexable has used its model of quality and flexibility to deliver what few others can. With six global patents surrounding their microwave sintering processes, Indexable can output ceramic inserts with ultra-fine-grained microstructures that yield increased hardness, toughness, and thermal stability versus traditional ceramic grades in the same categories. Their emphasis on quality, which is supported by their ISO9001:2015 certification,


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TRIAX TECHNOLOGIES RAISES $12.5 MILLION SERIES A FUNDING

Triax Technologies has raised a Series A funding round of $12.5 million. The round, led by McRock Capital, an institutional investor focused on industrial IoT, along with Connecticut Innovations and support from existing shareholders, will be used to grow the Triax team and scale its solutions globally. As part of the financing, Scott MacDonald, cofounder and managing partner of McRock Capital, has joined the Triax board.

The funding comes amid growing demand for, and investment in, IoT technology, and increased adoption of the company's wearable solutions to improve worksite safety and efficiency.

"Our mission is to provide IoT technology and data insights that help companies change the way they work to keep workers safer and worksites more efficient," says Robert Costantini, CEO of Triax. "By working closely with innovative customers, we have demonstrated the ability to service large-scale operations with robust and scalable technology, and to serve as a trusted partner in their digital transformation initiatives." Building on the market demand for this real-time worker alert technology, Triax launched Spot-r Radius in May 2021. This next-generation solution leverages preventative alerts with added safety and efficiency data insights.

AMERICARES, XYLEM PARTNERSHIP DELIVERS CLEAN WATER AND SANITATION TO 3.5 MILLION PEOPLE

Xylem Watermark, the corporate social responsibility program of Xylem Inc., and health-focused relief and development organization, Americares, aim to reach one million people in 2021, through their collaboration to improve access to clean water and sanitation. The program builds on the first year of the partnership, which delivered clean water and sanitation services to over 3.5 million people, helping to slow the spread of COVID-19.

In 2021, the partners will provide water, sanitation, and hygiene (WASH) infrastructure repairs and education to frontline healthcare workers and communities across six countries including India and Bangladesh, currently experiencing COVID-19 spikes. In Mumbai, where informal, urban settlement communities are particularly impacted by the second wave of the pandemic, interventions will include rehabilitating WASH facilities at healthcare facilities, serving 70,000 people from the city's most low-income areas. The partners will also

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provide WASH assistance to disaster-prone coastal communities in Bangladesh.

"Through our partnership with Americares we aim to bring this message to life for communities around the world and to empower them through improved access to clean water and sanitation," says Austin Alexander, vice president of sustainability and social impact at Xylem.

ATLAS COPCO POWER TECHNIQUE ANNOUNCES NEW POSITIONS

Atlas Copco Power Technique names Jim O'Brien as the vice president of strategic accounts, effective immediately. O'Brien has been a part of the Atlas Copco group since 2000. Originally joined the Atlas Copco group twenty-one years ago, O'Brien started his journey with Atlas Copco as a key account manager for General Motors. In 2007, O'Brien was promoted to global key customer manager for portable energy, working in Belgium and stationed in Shanghai. In 2013, O'Brien returned to the United States to serve as the integration manager for American Pneumatic Tools. With O'Brien's background and experience, he is a strong fit for this newly created position.

Along with O'Brien, Atlas Copco Power Technique names Meadow McClure as the strategic accounts specialist, assisting designated strategic accounts to help maintain and grow customer share within current accounts. McClure has been with the Atlas Copco group for eight years. She started her journey as a service coordinator for BeaconMedaes, then later moved to the role of equipment coordinator for Power Technique North America. Now, McClure's main responsibility is assisting with customer service on major accounts and supporting any urgencies.

SOFTINWAY WINS NASA SBIR CONTRACT, CHANGING TURBOMACHINERY DESIGN METHODOLOGY

SoftInWay has been awarded a NASA SBIR contract to leverage artificial intelligence to improve turbomachinery designs for use in high power-density engines. Thanks to the team's efforts, SoftInWay was awarded the Phase II contract to expand upon its work developing an axial compressor map generation program that leverages an autonomous self-training AI. This project will redefine turbomachinery research and development, enabling companies to develop reliable and efficient technology faster.

After being awarded the Phase I contract back in September, the SoftInWay engineering team has partnered with engineers from Raytheon Technologies, a leading defense contractor in the United States, and researchers from Purdue University, a leading institution in turbomachinery research and education. SoftInWay will work with these two partners to further refine the developed AI-based program by making it applicable to a wide variety of axial compressors, a key component in making powerful yet efficient gas turbine engines for airbreathing propulsion, without the need to retrain the AI. ◆

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Sarasota Banking on New Lift Station To Stop Messy Sewage Spills

When environmental damage threatens paradise, a creative plan provides the solution

By Thomas Renner

People have discovered there is a lot to like in Sarasota, Florida. Fewer than 1,000 people called the city home in the early 1900s. Its population now approaches 60,000, with an increase of more than 12 percent since 2010. Like the rest of the county with the same name, the city on the state's western side has seen a significant rise in citizenship.

The motives are many: weather, culture, recreational activities, and affordable housing are among the reasons people have flocked to the community. Sarasota Bay's

Lift Station 87 in Florida will have a capacity of 9.5 million gallons per day, treating about 33 percent of the city's wastewater. (photo credit: Charlie Fernandes Photography)

abundant marine life, plentiful variety of plants and exotic birds add to the appeal, along with opportunities for fishing, kayaking, and water sports activities. Sarasota County attracts more than 2.2 million annual visitors, accounting for $2.24 billion in total economic impact. By any measure, Sarasota has got the goods.

Sewage spills can detract from the appeal of any community, and they seem particularly problematic in Sarasota. "The overall health of the bay has regressed in many ways over the past decade," Orion Morton, a kayak tour guide and advocate for Sarasota Bay wrote in the Herald-Tribune newspaper in April. "We have become accustomed to sewage leaks."

A 500,000-gallon sewage link in February 2004 in the city provided the impetus for a new lift station to handle approximately one-third of the city's wastewater flow. Lift Station 87, which opened late in 2020, will replace Lift Station 7, an aging facility that contributed to city's sewage control problems. After the spill in 2004, another 500,000-gallon spill just seven months later sparked community outrage.

The problems, it turns out, were just beginning. The road to completing the new lift station—at a reported final cost of $67 million—was complicated, lengthy, and costly.

ROCKY START

Neighbors complained to the city's public works department about foul odors emanating from Lift Station 7 almost from the beginning after it was constructed in the 1980s. Other city officials, however, had been unaware of resident complaints.

Tensions reached a boiling point in February 2005. Residents learned about the 2004 spill only after the incident one year later. Michael McNees, Sarasota's city manager at the time, defended city employees, further angering residents. In August 2005, six public works employees were demoted, reprimanded, or forced to retire. McNees left his position as the city's chief executive in 2007.

The state's Department of Environmental Protection established a 2011 deadline to move the city's Lift Station from Pomelo Avenue. Luke Wood Park was determined to be the best site in terms of efficiency and cost. The city estimated the project would cost $8.5 million.

The city awarded Westra Construction Corporation a $9.6 million contract in February 2011. AECOM served as the initial project engineer, and teams estimated to have the station completed in 2012.

A BIG LIFT FOR FLORIDA COMMUNITY

WHAT: Lift Station 87 in Sarasota, Florida, is a new above-ground station with a 9.5 million gallon per-day capacity.

WHY: The project is necessary to improve the wastewater system and mitigate overflows due to aging infrastructure and equipment. It will replace Lift Station 7, which will be decommissioned and the site will be restored and landscaped to its park-like setting. The new station will handle about 33 percent of the city's wastewater flow.

HURRICANE-PROOF: The two-story building was designed to withstand the impact of a Category 3 hurricane. The design will allow Sarasota Memorial Hospital and other critical designated storm shelters to remain operational after a storm. City officials directed the project engineer, McKim & Creed, to bring critical equipment above ground to a height above Category 3 storm surge elevation.

CUSTOM FLOOR DOORS: Thirteen floor doors from BILCO were installed in the project, and include factory-installed fall protection grating. The doors were customized to meet unique size requirements.

DID YOU KNOW? Sarasota has been impacted, directly or indirectly, thirty-six times in the last 146 years by hurricanes. The city is brushed or hit by hurricanes every 2.16 years.

Thirteen floor doors manufactured by BILCO were included in a new lift station in Sarasota, Florida.

Construction began in June 2011, but more problems quickly surfaced.

ANOTHER SPILL

Just two months after work began, another spill—this one not caused by aging Lift Station 7—pushed the project in a new direction. A contractor inadvertently broke a force main, causing an estimated spill of 200 gallons into the Hudson Bayou, a Sarasota Bay tributary. AECOM and Westra were terminated, stopping work on the project. An article in the Sarasota News Leader magazine said contractors were on the verge of drilling into a support slab of the Osprey Avenue bridge. "We're very lucky we didn't have a catastrophe with our utility department," then-Mayor Shannon Snyder says.

McKim & Creed took over as the project engineer in 2013 and after an evaluation phase, made two significant changes to the project. The new team wanted to build a new, above-ground "hurricane-proof" lift station, designed to withstand Category 3 hurricanes.

The new model also required digging eight-feet further down to construct microtunnels to convey waste. Engineers believed the bridge might have collapsed in the soft silt base around the bridge without the deeper microtunnels.

While necessary, the new design was more time-consuming and costly. Previous work also needed to be done over. Work on microtunnels started in January 2017, and estimates increased from $27.1 million in 2014 to $32 million in 2015 and finally, $54.1 million in 2017.

THE BIG DIG

Microtunneling was one of the most significant decisions made by McKim & Creed for the project. A trenchless method of sewer construction, the process is effective in soft, unstable soils. The tunneling process is remotely controlled and involves digging a sending and receiving pit, placing a microtunnel boring machine into the sending pit, cutting a hole through the ground and pushing the new sewer pipe in place. Workers then have to remove the microtunnel boring machine.

A jacking rig, functioning similar to a jack hammer, pushes the new sewer pipe in place. The process is slow, progressing about 20-40 feet per day. "You're underground, chewing through rock, under a historic bridge, and in an environmentally sensitive area," McKim & Creed's Robert Garland, P.E., said in a radio interview. "We went about this in a methodical way."

While slow, the advantage is that the process does not disturb the surface above. The bridge, and the sensitive environment in Hudson Bay, concerned Sarasota officials and McKim & Creed. Wastewater is carried through a 36-inch PVC pipe in the microtunnel, and it is encased in a 60-inch casing.

"We put the steel casing in first, which is the wall of the tunnel," Garland said. "Inside that casing will be the pipe that carries the wastewater. It helps us in the construction, but if there is any failure of the pipe, it is contained within that casing."

Work on the 670-foot microtunnel under the bridge began in January of 2017. The Osprey Avenue Bridge, which was closed in 2016, opened in June of 2017. The project also included a 560-foot long microtunnel under Luke Wood Park that connects to Lift Station 87 and with the microtunnel installed under the Hudson Bayou.

TWO-STORY LIFT STATION

The other critical change designed by McKim & Creed included the construction of a two-story lift station designed to withstand strong hurricanes. Sarasota Memorial Hospital and storm shelters will be served by the new station. Maintaining operations during hurricanes was an important concern for city officials and residents as a hurricane or tropical storm brushes the city, on average, every other year.

The building includes HVAC and equipment exhausts in the towers, and the two-story building was built over a new, 50-foot deep wet well. It has a maximum capacity of 9.5 million gallons per day.

PCL Construction installed thirteen doors from BILCO in the lift station. The doors were manufactured in a wide range of sizes and allow access to vaults, pipes, and pumps in the wet well. The floor doors are constructed from aluminum with stainless steel hardware for corrosion resistance and are reinforced for H-20 loading to withstand the force of heavy equipment vehicles used at the facility.

The BILCO doors will allow access to pumps and vaults for workers at the lift station.

"The doors are durable, and they are a good product for this application because they are aluminum and won't be as impacted by corrosive gases and water," says Cory Westphal, an assistant project manager for PCL. "It was a fairly standard installation except that they were installed before the building was finished. The building was built around the doors."

PCL ordered the doors through Building Specialties of Bradenton, which worked with them to manufacture special sizes. "BILCO was selected because they had the capability to make very large hatches," Westphal says. "Competitors had difficulty building the sizes we needed and meeting the loading requirements. The ability to make them that large and meet those requirements was essential. They were prepared because they build doors like this frequently and they knew how to do it."

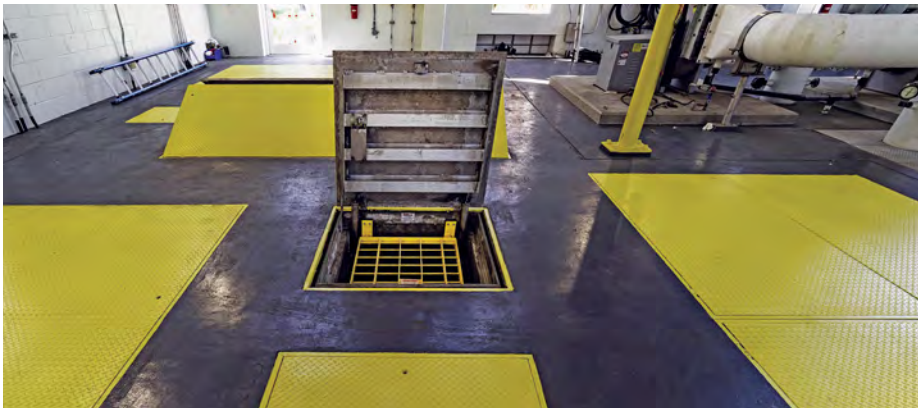
FINAL LEG

The final phase included the installation of a 24-inch diameter gravity wastewater pipeline by open cut to connect homes and businesses to the new lines. Crews also replaced aging ductile iron and asbestos cement pipe, installed new reclaimed water mains and replaced storm sewers. New curbs, sidewalks, and drainage improvements were included. Osprey Avenue, which had been closed earlier in the process for the digging of the microtunnels, was closed again from June 2020 through March 2021.

Wastewater flow was diverted to Lift Station 87, and Lift Station 7, seventeen years after its failing systems surfaced, will eventually be demolished and restored to a park-like setting. The final price will amount to about $67 million, and that figure includes $48.6 million for planning and construction, according to reports.

For city officials and residents, the project's completion is noteworthy, but hardly celebratory. "I think we need to own up to it and explain to the community what happened so that we and future commissioners don't have the same problem or learn from those mistakes," Commissioner Hagen Brody told the Herald-Tribune last September. ◆

The BILCO doors are designed to withstand the force of heavy equipment.



Thomas Renner writes on building, construction, engineering, and other trade industry topics for publications throughout the United States.

Seattle Takes FOG Program Online

Improving remote access and customer compliance

By Chris Weinandt, Aquatic Informatics

With more than 5,000 restaurants and food service establishments (FSEs) in Seattle, the city's fats, oils, and grease (FOG) program is vital to protecting community health and keeping sewers flowing by preventing unlawful discharges from entering the system. With a team of five inspectors and one program supervisor responsible for a large program, Gary Christiansen, program supervisor for the Wastewater Source Control Program (WSCP) at Seattle Public Utilities, needs to optimize on efficiencies wherever possible.

"The reality is our small team is not able to inspect every Food Service Establishment (FSE) immediately; our success depends on identifying problem areas and prioritizing establishments that require the greatest attention. Our overarching goal is to create a data-driven vs. an effort-driven program in order to serve the City of Seattle in a cost effective and efficient manner," says Christiansen.

OPTIMIZING EXISTING PROGRAMS

For a little over fifteen years, the city has used Linko, a software program that tracks data from FSEs, as well as ArcGIS that maps sewer lines, connections, and identifies hotspots. The problem was these two systems were not integrated, but if they were, the city could use its GIS system to identify which FSEs were discharging to which service connections and then cross-reference that data with its FOG data.

Seattle Wastewater Source Control team.

"We realized if we connected these two software solutions, we would be able to better manage our FOG program, automate tasks that were time-consuming, and reduce human error in the process," says Christiansen.

INTEGRATION OF SOFTWARE PROGRAMS

Wastewater Source Control Program staff worked closely with the County Health Department, Food Safety Division to maintain an accurate listing of restaurants. By working with the permitting agency, SPU was able to set up regularly scheduled, automated reports containing the business information about active restaurants, new permits issued, and recently closed permits enabling them to keep their database of over 5,000 restaurants up to date. Once the permit data is received, it is married with the results of SSO, maintenance data, and CCTV findings and uploaded into GIS. To bring the GIS data into the Linko platform, WSCP staff contracted Linko to design and build an import feature to allow for the integration of data between GIS and the FOG software. After a few months, the integration between the FOG software and GIS was complete.

When the city receives the automated reports, data is entered and categorized by the GIS system. The team is then able—at the click of a button—to send information from ArcGIS directly to the Linko database. Previously, this information would have been entered manually and updated annually based on a list of several hundred new facilities.

Integrating the two major software systems allowed certain data elements to be shared between the systems. Now, the FOG software can seamlessly schedule initial inspections for new facilities—and ensure new businesses are not missed.

"By consolidating GIS and other data into the FOG software, we can get a much more accurate picture of the network, connections to FSEs, and the condition of actual sewers, which really helps us pinpoint problem areas and reduce problems overall," says Christiansen.

DIGITIZING DATA ENTRY

Now that the two programs were working well together, Christiansen had a vision to further improve data accessibility and streamline processes by taking the whole program online. "Cloud native applications enable our inspectors to access all of our facility information from the office, in the field, and in the current COVID-19-work environment—from their homes utilizing a laptop or tablet, even their smartphones. We have already experienced the efficiencies of integrating previously-siloed data between the FOG and GIS systems. The first step to taking the program online was to optimize the digitization of processes. Next, we intend to move to online maintenance reporting," adds Christiansen.

A natural extension for the city was to add Linko Remote Inspector, a software tool that digitizes inspection data and standardizes the data gathered during inspections. "Prior to this, we had paper forms that didn't have a lot of direct questions and were very text-based," explains Christiansen. "The inspector would write his or her findings and what they thought was relevant onto these paper-based forms, with no specific direction to ensure basic information was captured." Often, this led to many more questions by the FSE and corrective actions would require multiple follow-ups before the action could be resolved.

In addition, when hotspots occurred, there were no warnings or indications because no data was available for analysis. Instead, as hotspots were identified, the city would send out inspectors—a reactive approach that meant no preventative steps were being taken, resulting in a backlog of inspections.

The smart forms introduced with Remote Inspector allow inspectors to enter findings into their mobile device directly from the field. By creating standardized digital forms, the city can now quickly and easily specify what data must be collected and build a baseline for better analysis.

STREAMLINING RISK ASSESSMENT

The second instrumental form or process to be digitized was a facility's FOG risk assessment, which is a ranking based on key factors.

Angelique Hockett, a city FOG inspector who established the Risk Priority Assessment ranking for the FOG program, says, "If we had a sanitary sewer overflow (SSO) on a main line, that line was given a unique number if SSO and CCTV crews had identified grease. I would then join the lines in the GIS software and a summation of the various criteria would dictate a hotspot category per facility. There are thirty-seven different ranking numbers, organized to fit into six hotspot categories." From there, Hockett would manually assign inspections for each facility using data from the asset management software and its basic information.

Armed with the new smart forms in Remote Inspector, the inspector completes a questionnaire with information observed during the inspection. The form then calculates the results, assigning points to determine the facility's FOG discharge risk. The smart form combines the FOG discharge risk with the Hotspot category and automatically assigns an overall FOG risk value. Based on the FOG risk value, the software automatically sets a tailored inspection schedule for the facility, allowing SPU to schedule resources in sync with actual need out in the field. Meaning, FSEs that require more touches are scheduled as such, and those needing less touch are scheduled accordingly as well. "Digitizing this process has improved accuracy and enables us to take preventative action before hotspots occur," concludes Hockett.

Linko Remote Inspector allows inspectors to easily collect data electronically in the field.

MOVING ONLINE

With digitized processes in place, moving the city's FOG program online has several advantages. Being accessible through a browser, it can now be used on any connected mobile device or computer. The look, feel, and function of the software remains consistent, making it easier to use and access the entire suite of FOG software from anywhere. "The uniformity that comes along with a cloud application makes it a lot more efficient and gives us flexibility for the future as the city grows," says Christiansen.

FOSTERING PARTNERSHIPS WITH FSE

Once an inspection has been completed, inspectors can easily email a copy of the completed inspection form to the FSE. Previously, the recipient of the inspection report received a copy of the paper form along with an inspector's business card. The form included handwritten comments about what corrective actions needed to be taken, which weren't always clearly stated and required subsequent follow-up visits to ensure action was taken. Now, a report is emailed directly to the FSE with specific corrective action information. From a compliance perspective, this helps ensure all parties clearly understand the city's expectations. This has helped the city dramatically improve relationships with FSEs. The city can now receive an email with pictures when something is cleaned or corrected, meaning that staff don't need to go back to the establishment to verify the problem is fixed.

"Since deploying the FOG management software we have been able to increase the number of our inspections by 316 percent over four years. The new program has improved work processes, like route planning and reduced admin time by bringing everything online, so we are able to visit more sites which is a good thing for Seattle's sewer system," concludes Christiansen. ◆

Chris Weinandt is the Aquatic Informatics product manager for Linko and Tokay. Weinandt has been with Aquatic Informatics for over eighteen years where he has helped build and deliver software solutions for fats, oils, and grease; industrial pre-treatment; liquid hauled waste; and cross connection control and backflow prevention. Weinandt focuses on delivering software features and functionality that drive efficiencies and better informed and timely decisions. For more information, visit **www.aquaticinformatics.com**.

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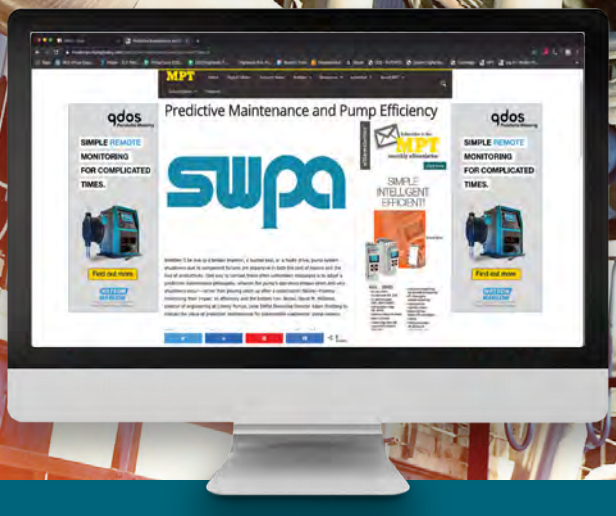

FOR MORE INFORMATION:

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Scanning Accurate Models of Harsh Environments

New 3D reality capture technology proves a cost-effective, reliable, and safe solution

By Dean Solberg and Steve Young, Exact Metrology

Many industrial sites present inhospitable environments, where the health and safety of the employees and visitors are at risk due to temperature, corrosive materials, moving machinery, and heavy objects. In addition, sites often have networks of pipes, tunnels, storage vessels and other structures that need to be examined. 3D reality capture permits complete site visualization for safety training. Site visibility also greatly improves plant management efficiency. Accurate measurements help designers create extensions without needing to visit the site and enhanced planning of workflow avoids disruptions.

3D reality capture is a process of scanning and capturing any site, for example, factories, buildings, crashes, and crime scenes, in a 3D digital model, combining measurements and imagery. The model can be used for design and comparison purposes in various situations, capturing every detail with to-the-millimeter accuracy. This technology combines one-touch operation with portability and speed to deliver high levels of accuracy, automation, and the ability to create 3D environments in a matter of minutes.

3D REALITY CAPTURE UP CLOSE

Exact Metrology, a comprehensive metrology service provider and an architectural scanning company, is proud to announce the immediate availability of the Leica RTC360 3D laser scanner. Manufactured by Leica Geosystems and distributed by Exact Metrology, these portable coordinate measuring machines are designed to measure large-scale objects. This laser scanner uses 3D reality capture.

Thanks to 3D reality capture, building information modeling (BIM) experts save time and money as BIM processes become more efficient, from the accuracy of construction documentation to design and build quality assurance. The latest laser scanning technological developments improve understanding and documentation of the build environment through the use of millimeter-accurate laser scanning and high-dynamic range (HDR) imagery. By using 3D reality capture, previews of data and imagery are viewable onsite directly from a tablet, enabling scans to be checked and verified before going to the office.

ACCURATE AND RELIABLE

The RTC360 3D Reality capture scanner is ideal for professionals managing project complexities with accurate and reliable 3D representations. This scanner effectively combines a high-performance 3D laser scanner with Leica Cyclone Field 360, a mobile device app for edge computing that automatically registers scans in real time and Leica Cyclone Register 360, an office software that integrates the 3D model into the workflow. Additional features include capturing scans, including enriching HDR imagery in less than two minutes, automatically recording moves from

station to station, and augmenting data capture with information tags.

Using 3D technology is useful when a crash or crime scene requires quick analysis of the scene. Scanning creates a 3D environment that can be explored and analyzed, as well as documents the entire scene in detail. Furthermore, fast scanning minimizes disruption and delays and removes scene degradation, thus providing jurors with credible evidence. Security and site validation at public events are likewise very important and an accurate model of the area can highlight threats and risks not readily evident.

REAL-TIME MEASUREMENTS AND HIGH-QUALITY SCANS

With a measuring rate up to two million points per second, automated targetless field registration (based on VIS technology) and automated transfer of data from site to office, the device and software greatly reduce time spent in the field and maximize productivity.

The scanner's portable design and collapsible tripod fit into most backpacks. Low noise data allows for better images, resulting in crisp, high-quality scans that can be used in a variety of applications.

As part of the RTC360 solution, the Cyclone Field 360 links the 3D data acquisition in the field with the laser scanner and data registration in the office with Cyclone Register 360. The user can automatically capture, register and examine scan and image data. ◆

Exact Metrology is ISO9001, AS9100 certified as well as FFL and ITAR registered. With facilities in Cincinnati, Ohio; Moline, Illinois; and Milwaukee, Wisconsin, plus affiliated offices throughout the country, Exact Metrology is a comprehensive metrology services provider, offering customers 3D and CT scanning, reverse engineering, quality inspection, product development, and 2D drawings. The company also provides turnkey metrology solutions, including equipment sales and lease/rental arrangements. For more information, visit **www.exactmetrology.com**

Pump Industry Prepares for the Brain Drain

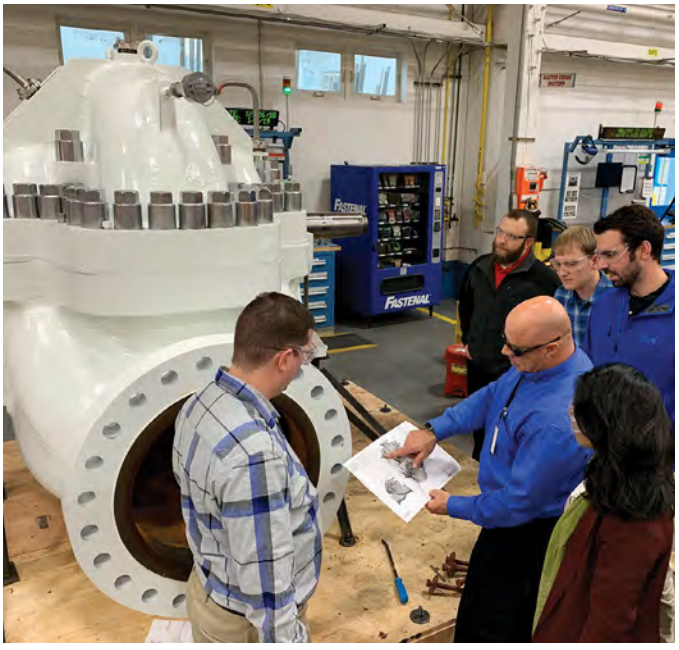
Retirees cause massive shortage in trades jobs, so what's the best solution?

By David Fasnacht, Sulzer Pump Services Inc.

As more baby boomers continue to retire in 2021, it is reported that 62 percent of companies are struggling to fill critical, skilled technical trade positions, such as millwrights, machinists, mechanics, welders, operators, pipefitters, and electricians. Thirty-one million skilled technical trade positions will be vacant by the end of 2021, per the 2020 U.S. Labor Department Report.

Skilled tradespeople are key components to the domestic workforce and are vital to the economy. The need for skilled technical trade labor training is only becoming more evident. Today's maintenance facilities manufacturing facilities, power plants, pipelines, water processing plants, and chemical plants have employees with decades of experience retiring with their intimate knowledge of the equipment and processes.

Understanding the technical aspects of pump operation can improve operator performance.



These plants supply us with electricity, water, gas, and diesel for our vehicles and heat in our houses, just to mention a few necessary living requirements. Jobs that supply our everyday needs cannot be outsourced. In a perfect world, the trade's person retiring would be paired with their replacement, for six months to a year, to learn all the tricks of the trades that have been mastered by the senior employee over their decades of employment.

ENTRY-LEVEL TRAINING

Due to cost constraints, companies rarely invest in training new employees prior to the retirement of their predecessors. The need for skilled, entry-level employees is becoming so great that employers are starting to look at many ways to find qualified personnel.

Some companies are starting to work with the local trade schools in their areas. These trade schools have substantial access to manufacturing and processing plants in their area to develop the specific training required for manual maintenance operations and automated operations at these facilities.

Companies may need to revisit company-specific apprenticeship/mentorship programs to ensure they have a qualified employee base. In the past, companies had training programs available to interested, new talent. One of the challenges industries are being faced with is the shallow talent pool from which to draw a skilled tradesperson. Companies may receive 400 applications but only six of those applicants are qualified for the skilled labor trade job available.

REAL-WORLD SKILLS

Training programs can range from a thirty-minute online seminar to two- to five-year programs / mentorships. The goal of the two- to five-year programs / mentorships is to have a skilled technical tradesperson with the company's required specific skillsets.

The reality is trade schools do not offer many classes for the manual processes and the real-life skills needed in these manufacturing facilities. Most of the chemical plants, maintenance facilities, and refineries have little use for automated machining of parts. The facilities may need to machine one or two parts, not thousands, thus making manual machining processes necessary. This creates a disconnect between outside/third-party training offered and the actual needs of the facilities.

New employees need exposure to and training for all aspects of the processes and the equipment in the shortest time possible, which can be achieved by tribal knowledge—retiring employees and training classes.

Regular training sessions offer a great return on investment.

From the viewpoint of a skilled technical tradesperson, already working in the industries mentioned, the training type and timing is of the utmost importance. The employers must invest in the new employees' internal training, so the company can perform efficiently and safely and maintain a healthy profit margin. Internal training can also supply the

Broadening the knowledge base of the younger generation helps to retain valuable information within the organization.

employees with critical information and hands-on experience, thus decreasing the learning curve and minimizing unnecessary mistakes.

FILLING THE KNOWLEDGE GAP

Lack of training can work in two ways in a manufacturing plant. For example, operations personnel may not understand how running a centrifugal pump incorrectly increases the frequency of repairs, which could otherwise be avoided; in addition, maintenance personnel may not understand why they are repairing the equipment so often. This lack of knowledge can cost the employers excessive, unnecessary downtime, loss of production and the added maintenance costs, leading to significant revenue losses.

The rate of return for a company investing in their employees' training is hard to gauge, but training is extremely beneficial to the maintenance of the facility while keeping downtime and unnecessary repair costs to a minimum. Every training session, whether it is a thirty-minute, online seminar or a three-day, face to face seminar with hands-on training, can have an enormous rate of return for the facility, thus decreasing costs and increasing efficiency as well as safety.

If a company were to send a tradesperson to attend one subject-specific class, once a year for five years, pertaining directly to the equipment supported, tremendous benefits and cost savings will be achieved in production and safety. Ongoing training programs can ensure staff are well qualified for their positions.

Investment in training is vital for the support of new employees and their development within the company.

BECOMING QUALIFIED

Take for example an employee who is personally responsible for the successful installation, rebuilding and maintenance of centrifugal pumps. The most benefit would be obtained by attending a centrifugal pump fundamentals course, which supplies a solid foundation of installation, operation and maintenance of rotating equipment. This also satisfies the OSHA Codes of Federal Regulations (CFR) 1910.399 requirement. OSHA defines a "qualified person" as "one who has received training in and has demonstrated skills and knowledge in the construction and operation of electrical,

equipment and installations and the hazards involved."

When applied to pumps and systems, a qualified person can demonstrate relevant skills and knowledge related to the installation, operation and maintenance of such equipment and systems. In addition, the employee will receive the safety training needed to identify and avoid hazards, including the proper identification and use of personal protective equipment and proper lockout/tagout procedures. Instructor-led training teaches the basics along with the safety knowledge needed to meet OSHA's "qualified person" definition.

The learning curve can be exceptionally steep when people begin their trades careers. Mistakes are not acceptable. Companies must invest in their employees if they expect them to perform at the elevated level needed to compete in today's business world.

EMPLOYEE INVESTMENT

Training is often the first thing to be cut in tough economic times, making for enormous ramifications, considering 20 to 60 percent of the skilled trades employees in most facilities have been hired in the last five years.

Businesses must invest in the talent that they currently employ and plan on hiring. Employee investment will provide years of successful operations with a minimal amount of growing pains, as the baby boomers retire.

The shortage of skilled trades workers today is unprecedented. Therefore, training is critical for the future success of a facility. Employers must supply the training necessary, as the hiring pool is young and inexperienced, which will give the companies the best chance for a smooth transition from the retiring employees to the new hires.

There has never been a better time to be an ambitious, well-trained, skilled technical tradesperson. Being proactive instead of reactive with training is necessary for both the employer and employee in today's times. ◆

David Fasnacht is customer training manger for Sulzer Pump Services. Sulzer is a global leader in fluid engineering. The company specializes in pumping, agitation, mixing, separation, and application technologies for fluids of all types. Sulzer customers benefit from its commitment to innovation, performance, and quality and from our responsive network of 180 world-class production facilities and service centers across the globe. For more information, visit **www.sulzer.com**

Taking It to the Edge

Numerical simulation of the propagation of a gearbox crack

By Lin Liu and Suri Ganeriwala, SpectraQuest Inc.

In this article, fracture propagation is simulated using a finite element model for a gearbox that is designed for a rotor dynamic test rig. The circumferential plates of the gearbox are welded along the side as well as the bottom edges. Micro-cracks are usually generated at weld toes and the welding process will introduce residual stresses. The effect of the locations of initial fracture on fracture propagation path is studied.

INTRODUCTION

SpectraQuest Inc. specializes in design, development, and fabrication of gearbox system for diagnostics and prognostics researches. Upon request from a customer, we have performed a numerical simulation of crack propagation in a gearbox. The gearbox is installed in the Gearbox Dynamic Simulator, which is illustrated in figure 1.

The gearbox is made of six aluminum plate. Each one of the four circumferential plates is welded with one another. Furthermore, the circumferential plates are welded to the bottom plate. The top plate is bolted to the circumferential plates. A closer look of the gearbox is displayed in figure 2.

GEARBOX MODEL

The end plate of the gearbox facing the direction of the rotor "B" assembly is modeled in the work. The geometry of the plate is a 14 by 14 inches square with a 3-inch radius hole in the center. The thickness of the plate is 0.5 inches.

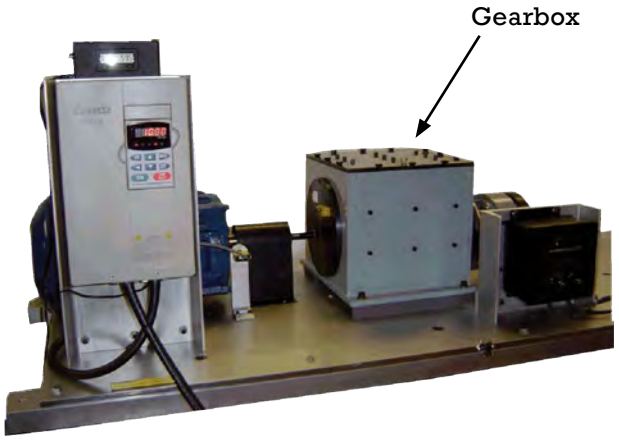


Figure 1: Gearbox in gearbox dynamic simulator.

Because of the small thickness of the plate, it can be considered as a plane stress problem and two-dimensional finite element model is created using FRANC2D software.

The finite element model is displayed in figure 3. There are total of 800 Q8 quadrilateral elements. The bottom edge is constrained both in the x and y directions. The assumed load is a node load applied at the uppermost node in the hole in the y direction with amplitude of 200 pounds.

An edge fracture is introduced on the left side of the plate with different initial locations. The three fracture initial locations studied in the work are displayed in figure 3. The lengths

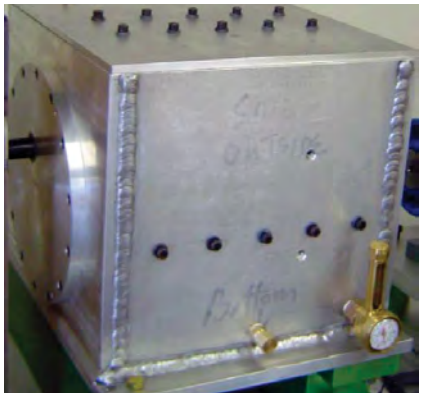


Figure 2: Gearbox.

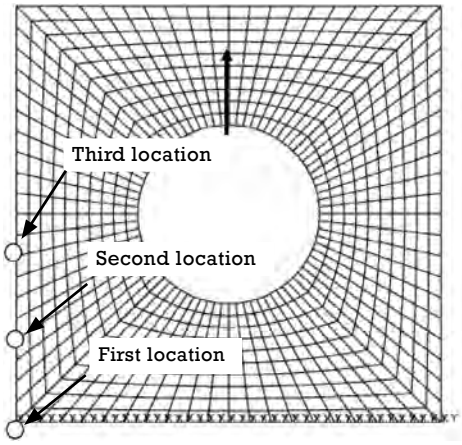


Figure 3: Finite element model of plate.

of three initial fractures are all 0.21 inches. And the initial crack direction is horizontal for all the three cases.

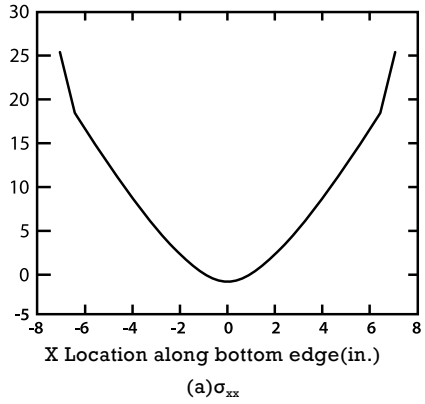
For each fracture studied, automatic fracture propagation is performed. The crack increment length is 0.2 inches, and fifteen steps are simulated.

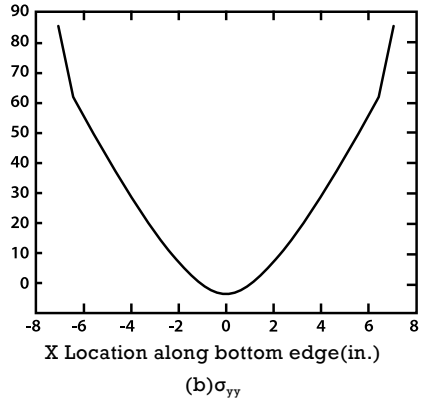
SIMULATION RESULTS

The tensile and compression stress bar distributions for a plate without fracture are displayed in figure 4.

The three sigma distributions along the bottom edge are displayed in figure 5. It can be noticed that the vertical external load will introduce normal stress in the horizontal direction as well as shear stress beside the normal stress in the vertical direction.

The software has the capability to remesh the cracked area every time the fracture is propagated. The mesh scheme after the first crack simulation is finished is displayed in figure 6. Note the refined mesh along the crack.





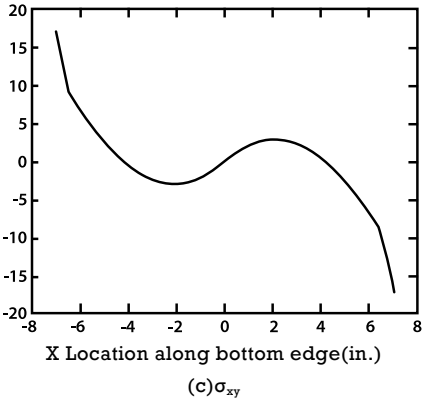
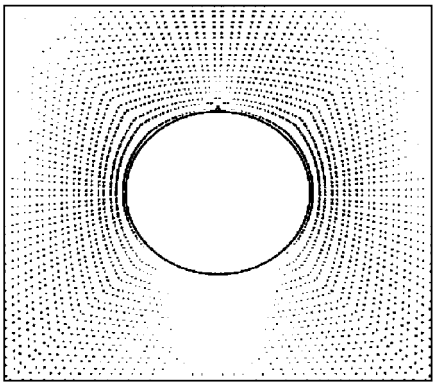


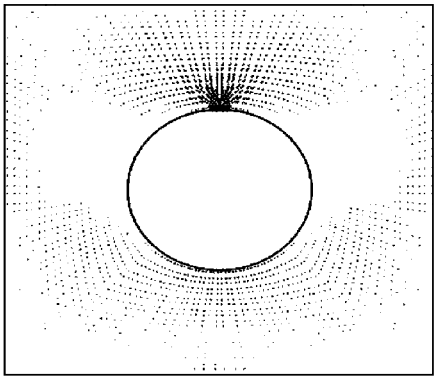
Figure 5: Stress distribution along the bottom edge.

The deformed mesh for the first crack case is displayed in figure 7. The deformation is amplified to make it distinguishable.

The crack propagation paths for the three crack cases are displayed in figure 8. The first crack, which has the lowest vertical initial location among the three cases, will propagate in an upward direction. The third crack, which has the highest vertical initial location among the three cases, will propagate in a downward direction. However, the second crack, which is initiated at a position between the



(a) tensile stress



(b) compression stress

Figure 4: Stress distribution in whole plate without fracture.

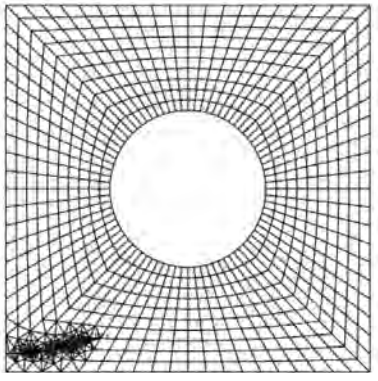


Figure 6: Remeshed area along the crack.

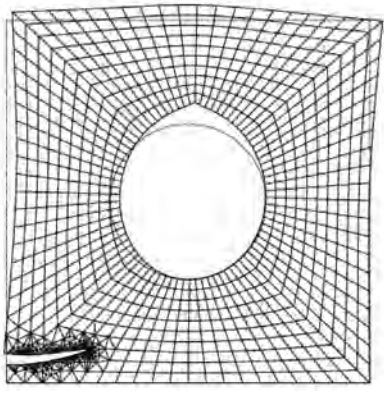
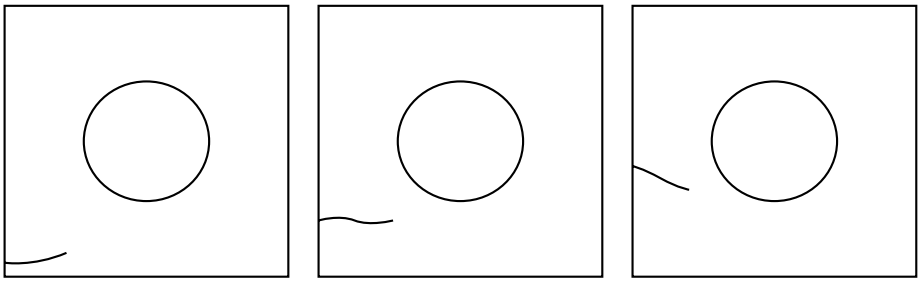
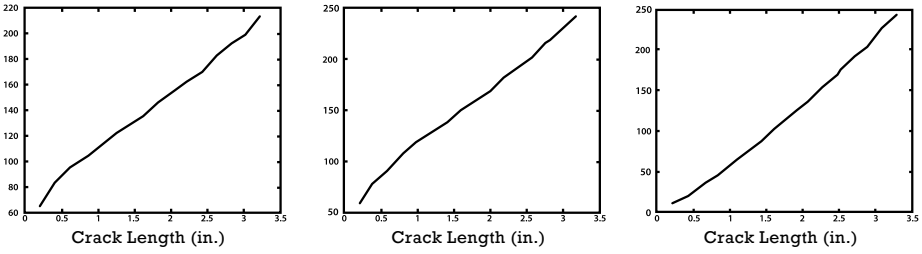


Figure 7: Deformed mesh for first crack.



(a) First crack (b) Second crack (c) Third crack

Figure 6: Remeshed area along the crack.



(a) First crack (b) Second crack (c) Third crack

Figure 6: Remeshed area along the crack.

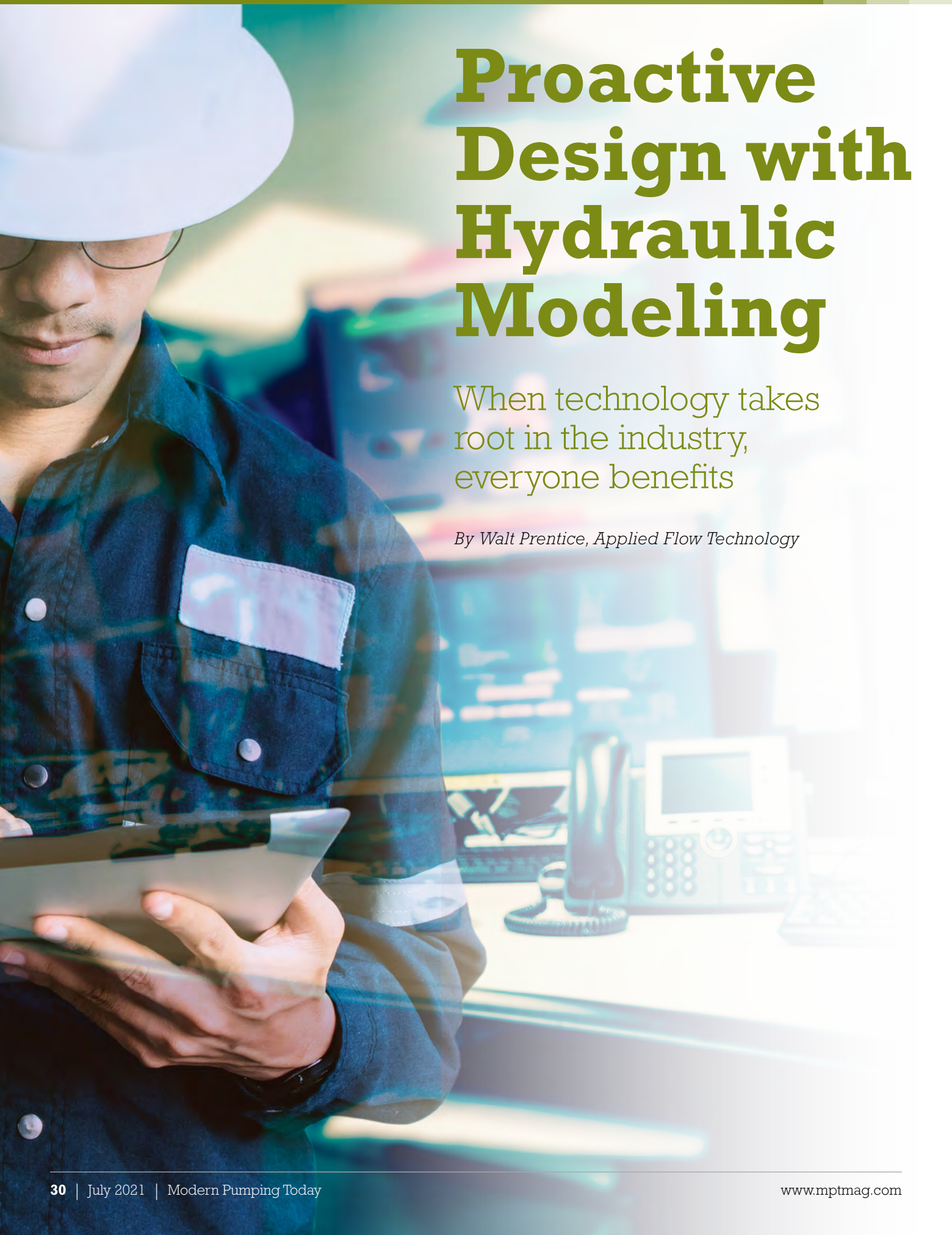
first and third cracks, will develop in a horizontal direction.

The Mode I stress intensity factor history for the three crack cases is displayed in figure 9. Figure 9 indicates second and third cracks have larger stress intensity factors which suggest faster fracture propagation.

CONCLUSIONS

Under the simulation conditions for this work, the results indicate an edge crack initiated close to the bottom of the plate has lower stress intensity factor than those initiated at a higher position along the plate side edge. An edge crack along the gearbox plate needs to be monitored carefully. ◆

SpectraQuest, Inc. is a leading developer and manufacturer of complete turn-key systems for training and diagnosis in machine vibration analysis, rotor balancing, and shaft/coupling alignment. System includes machinery fault simulators, interactive training program, data acquisition hardware/software, and accessories. To accelerate the learning and design process SpectraQuest offers a series of interactive software CDs on vibration fundamentals and calculations, signal processing, alignment, and balancing. For more information, visit **www.spectraquest.com**.



Proactive Design with Hydraulic Modeling

When technology takes root in the industry, everyone benefits

By Walt Prentice, Applied Flow Technology

No longer is over-engineering, or designing from heuristics, as necessary as it once was. Why? Because engineers can build and test systems in a computer rather than in the field. Flow analysis software has improved multiple facets of hydraulic system engineering. As technology improves, knowledge expands, and communication systems tighten, engineering teams can better prepare for unexpected events, design for the most efficient systems, and leave clearer footprints behind for future engineers to follow.

UNEXPECTED EVENTS

Things rarely go exactly as planned: in pumping systems and in life. At some point, an emergency shutdown or power failure will impact the system. In the past, the safe approach was to over-engineer the system to mitigate any perceived worst-case scenarios. However, the introduction of modeling software allows widespread testing of these scenarios to predict system responses without having to test in the field, or worse, to find out during the event itself. Yet, over-engineering is still common today. While better tools exist, it takes time for them to take root and become standardized. Two main reasons software modeling is advantageous are:

(1) The assumed worst-case scenarios often do not account for everything.

(2) Over-engineering leads to waste.

A common worst-case scenario is a waterhammer event and the resulting pressure surge. The failure of traditional methods for predicting waterhammer repercussions come from a lack of understanding the methods' limitations. Engineers must identify the maximum pressure that could arise in a piping system to ensure safety and meet code. Typically, that involves a few extreme assumptions, such as an instantaneous valve closure, and applying pressure-rise calculations. Yet there are three common situations that escape the engineer's view: line pack, wave reflections, and liquid column separation.

Figure 1 demonstrates how liquid column separation causes pressure spikes downstream of a fast valve closure. The initial pressure rise occurs on the upstream side from sudden flow stoppage, but the downstream side sees low pressure, causing vapor formation, leading to other pressure surges from vapor pocket collapse. Traditional analyses do not predict this and can leave the engineer with incorrect expectations.

The other problem with traditional approaches is waste. If systems are designed with unrealistically bad expectations, more money and resources are spent than necessary. This leads to higher costs, lower efficiency, and more complicated systems. Engineers should always design for the simplicist, most effective solution, which is best determined through modeling.

DO THE MATH

The math involved to analyze these situations is beyond what the average engineer cares to work out. This can lead to many simplifying assumptions, causing the analysis to deviate further and further from reality. If only engineers knew how accessible modeling accurate worst-case scenarios was.

EFFICIENCY AND COSTS

Current design is driven by the best and most cost-effective solution, not only one that gets the job done. Fluid modeling has improved both pump and system efficiency. For example, engineers can digitally build their system to determine what head rises are required for various flow rates and conditions. Then they can look at capital and operating costs to see what pump configuration is best suited.

One example of efficient software design was a refinery cooling loop redesign. It had four pumps in parallel as standard operation. One of them vibrated violently and eventually failed. After years of operational changes, no one had hydraulic models to see the effects until consultants were called to help. Modeling software revealed the problematic pump ran far outside its preferred operating region and that two pumps in parallel were more cost effective than four. Not only were operating costs reduced, but the remaining pumps would be running at their best efficiency point (BEP), as shown in figure 2.

This is not initially obvious because spreading the load across four pumps sounds less stressful than loading two. However, pumps are built to operate in certain regions, and factors like these must be considered during design. Without software, these efficiency sweet spots in complicated systems are much harder to identify. The study both extended pump life and saved $200,000 a year simply by modeling the system.

Similar thinking can be applied to pipe sizing, as there are both capital and operating costs to consider. Smaller pipes generally cost less, but they cause more frictional losses. This means the pump needs to supply more pressure than it would in larger pipes to drive the same flow. Hypothetically, though a pump may be sized "properly" according to the system proposal, that system may have been sized inappropriately, resulting

FIGURE 1

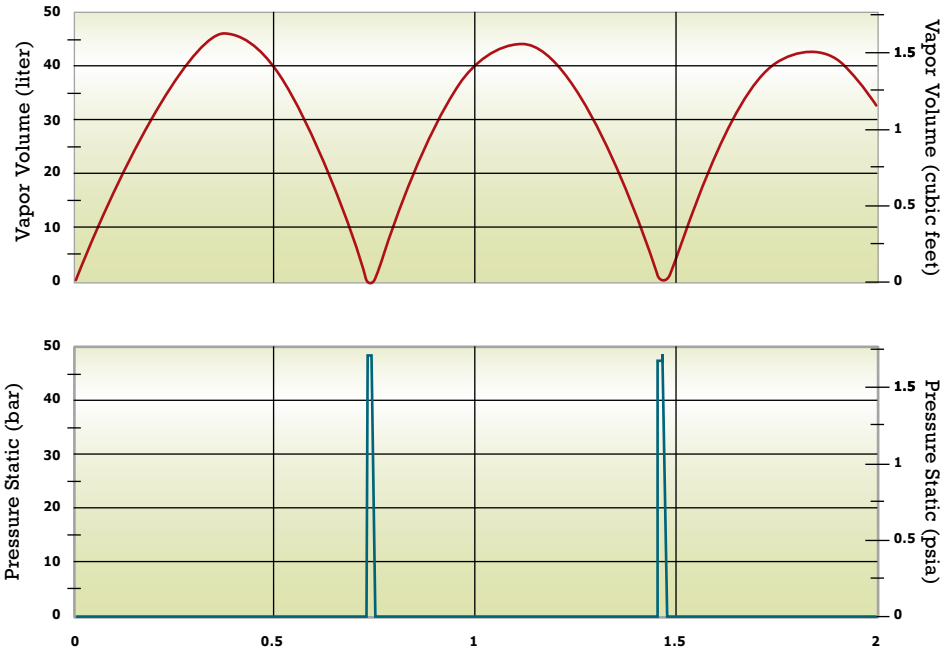


Figure 1: Transient activity immediately downstream of a sudden valve closure shows vapor volume (red, top) and pressure behavior (blue, bottom) present immediately downstream of the valve.

in the owner spending more money than necessary.

Considering all the factors that go into system sizing is overwhelming. It is impossible to view all the possibilities and choose the right one. This leaves engineers to size by heuristics or company standards. These days there is a much simpler, more effective way, and that is to plug all the design information into a computer, and let it do the heavy lifting. The result is a better system, if not the optimal, for both the designers and owners.

MOVING BEYOND SPREADSHEETS

Unfortunately, it is common for engineers to inherit spreadsheets or incomplete system drawings. Projects and ownership change over time, and these kinds of documents are rarely updated. Engineers then spend way too much time deciphering and fixing, rather than focusing on the

FIGURE 2

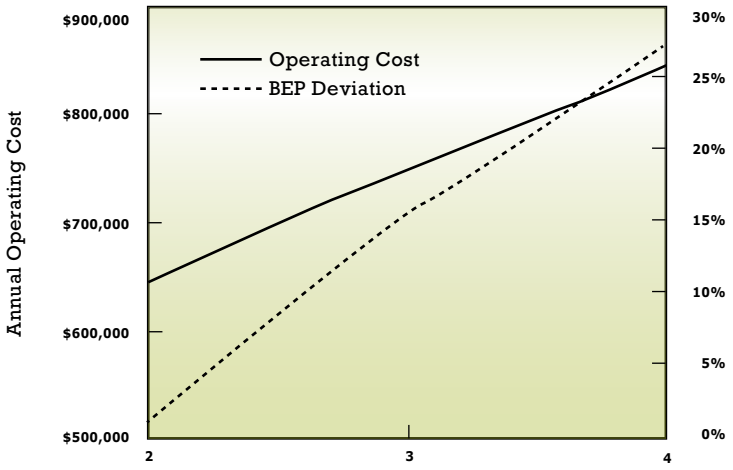


Figure 2: Annual operating cost and average deviation from the best efficiency point (BEP) decreased with number of parallel pumps in a refinery cooling water loop.

main task. Models improve the accessibility of the next engineers to do their analyses.

The practical benefits of having a prebuilt model are apparent. When an unexpected problem arises, the engineer can easily make changes and run tests to determine the cause. When repairs or replacements are needed, the engineer can model the effects of changing flow paths to see the effect on operation. When the owner needs an expansion, the engineer can model it for optimization. Any software learning curve is much easier to overcome than trying to comprehend incomprehensible documents and calculations.

Today's engineers have more standards, specializations, and tools than any generation before. Hydraulic modeling software is one tool that helps engineers accurately prepare for unexpected events, steer pump and system efficiency, and give future engineers better access to analysis. It is a bold step forward, but the benefits far outweigh any hesitation. ◆

Walt Prentice is a business applications engineer at Applied Flow Technology (AFT). Prentice holds a bachelor of science in chemical engineering with a minor in economics from the Colorado School of Mines. At AFT, he supports engineers around the world to troubleshoot their piping and ducting models. For more information, visit **www.aft.com**.

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SurgeWave™
Transient Monitoring System

Blacoh's patented SurgeWave™ Transient Monitoring System solves the need for industrial and municipal plant operators to detect and record transient pressure events occurring in water, wastewater, oil and gas, and industrial fluid applications. The system is unique in that it employs a system of dynamic pressure transducers and digital technology to monitor piping systems for indefinite periods of time. When a transient such as a pressure surge, pressure spike, or water hammer event is detected, the system activates a high-speed data recorder to record the event 100 times per second. Use SurgeWave to prevent pipe fatigue, breakage, cavitation, and assist in the modeling of corrective actions.

Often, plant operators do not find out about these dangerous abnormalities until much later when it is too late. With this Blacoh SurgeWave™ Transient Monitoring System installed, it will notify designers, engineers, manufacturers, and operators immediately within a few minutes of the event. They can assess pipeline performance, pressure, flow, and pump speed and perform the necessary corrections and maintenance

Unlike conventional data loggers, SurgeWave's high-speed data collection allows operators to detect any anomalies that would've otherwise gone undetected with insufficient recordings.

The SurgeWave™ Transient Monitoring System features include:

- High-speed data recorder instantly detects and records transient pressures up to 100 times per second
- Capable of capturing positive and negative pressures
- Software, website, and mobile app provide graphical analysis of recorded data
- Alert when any pressure transient is detected
- Set the limits of the system's normal operating pressure
- Receive email alerts if boundaries are exceeded
- Daily summary report of operations

For more information, visit www.blacohsurge.com.

NEPTUNE
NSP and NXP Series Pumps

Neptune is pleased to announce the availability of thirty-five additional models as part of the Phase II release of its NSP Series solenoid metering pumps and NXP Series stepper motor-driven metering pumps. The new additions will include more models with the acrylic degassing head (ACRYL) option, along with the standard polyvinyl chloride (PVC), polypropylene (PP), and polyvinylidene fluoride (PVDF) material options. The availability of these new models and material options significantly increases the application range of the NSP Series and NXP Series. For more information, visit www. psgdover.com/neptune.

MADISON CHEMICAL
MadBrew® Stone Acid

Madison Chemical introduces MadBrew® Stone Acid, a specially inhibited, low foam acid blend for the removal of hard water deposits and scale, extract from wort, lipids from hop compounds, and more. This unique formulation dissolves the crystalline molecular structure of the calcium carbonate, which permits the complete removal of the deposits from the kettle, heat exchanger, or other equipment. Ideal for stainless steel and copper alloys when used as directed, MadBrew® Stone Acid is ideal for craft breweries of all sizes and volumes, as well as food and beverage plants where hard water deposits and scale are problematic. For more information, visit www.madchem.com.

GORMAN-RUPP
EchoStorm Venturi Aeration Device

The EchoStorm, Gorman-Rupp's new static venturi aeration device, is designed to add dissolved oxygen into liquids as they are being pumped. It adds oxygen to wastewater, reduces the size of organic solids and degasses organic solids. The EchoStorm is available in 2-, 3-, 4-, and 6-inch sizes. Depending on the Gorman-Rupp pump it is paired with, the EchoStorm can provide flows from 50 to 1,300 gallons per minute with up to 857 pounds of dissolved oxygen per day. For more information, visit www.grpumps.com.

KIRLOSKAR BROTHERS LIMITED (KBL)
Autoprime Pump Unit

The Autoprime pump sets of Kirloskar Brothers Limited (KBL) is among the most preferred and ideal solutions for prompt dewatering or flood-control or wastewater management. This high-capacity, mobile flood-control and inland water-management unit is vastly used for dewatering the flood-affected areas during flood-like situations in monsoons. KBL's dedicated Autoprime pump set can be critically helpful in duly combating such flood-like situations as it facilitates quick dewatering of the waterlogged areas. For more information, visit www.kirloskarpumps.com.

Learning the Economics of Reliability

Pinnacle's Jeff Krimmel on the water industry's need for expansive capital investment

Reliability analytics company Pinnacle recently released its second Global Economics of Reliability Report, which analyzes the impact reliability has on the water and wastewater treatment industry. Built on direct operational and financial data from a diverse number of domestic water and wastewater operators, this report found that expenses on operations and maintenance is growing more quickly than capital expenditures, a sign that operators are underinvesting in assets today, sacrificing potential improvements in reliability and productivity. Jeff Krimmel, Pinnacle's director of data and market analysis, stopped by MPT's podcast to share details.

MPT: Before we talk numbers, what are some of the influences leading water and wastewater operators to squeeze extra life out of their existing assets through maintenance spending?

Jeff Krimmel: That's an issue that we had thought quite a bit about when we were contemplating putting this report together, and what path we wanted to pursue both analytically and then, just from the perspective of how we wanted to investigate this space more generally. What we found is that there are themes that have existed and are well known, well publicized, but they have real interesting manifestations in the operational and financial performance of water and wastewater treatment plants.

What I'm talking about are the broader impacts of climate change that we're familiar with and specifically some more acute stress, like what we see with COVID-19. These are just general public health implications that are growing, both in scale and severity and time and so on. Those two macro forces, in addition to a bunch of ongoing industry specific trends, mean that operators are trying, and for the most part succeeding, to harvest more value out of assets that are already in place.

So, from where we sat, we understood the forces that were pushing operators in that direction. We also understand that we're probably coming to the end of the gains that we would expect to see by trying to harvest more life out of existing assets.

MPT: It's tempting to talk about "infrastructure" as an expansive, nationwide project, but water and wastewater infrastructure can vary greatly depending on the region. How difficult did that make collecting and organizing the report's data to form a big picture?

Jeff Krimmel: It's a great question and it hits very close to home. Thinking about the effort that we went through and collecting all this data and the source data for the report that we built, we largely found it through annual reports and budget documents. It's capital improvement plan documentation from some of the largest municipalities around the country. And like you said, it's easy to talk about infrastructure writ large, but each one of these utilities has a different mix of assets that belong under this infrastructure umbrella and then, just on a facility by facility basis we can see a very different mix of assets at that level—much less at the portfolio level of assets across the whole utility.

So it's something that did immediately present some challenges in terms of introducing some apples-to-oranges effects in the data analysis that we were looking at. And while we acknowledge that it wasn't particularly problematic in the sense that the kinds of observations that we're pulling or the way these reports are built, we call them the "economics of reliability" reports. ◆

To listen to an extended version of this interview, be sure to subscribe to MPT's podcast, The Efficiency Point.

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