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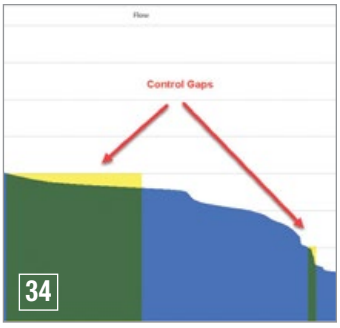

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FROM THE EDITOR

Compressed Air System Monitoring

Monitoring technology is widely available for compressed air systems to ensure they are running at peak performance.

Air compressor manufacturers provide sophisticated systems able to monitor and control compressed air systems. Italy-based Mattei Compressors is no different. I hope our readers enjoy the interview article I did with my long-time friend, Mr. Bill Kennedy, titled "Mattei Rotary Vane Technology Advancing Efficiency and Durability."

If plants want to increase the output and uptime of their production equipment, we highly recommend they monitor the compressed air use of the machines' pneumatic circuits. We thank EMERSON Machine Automation for sending us the article titled, "Improving Sustainability Through Compressed Air and Utilities Monitoring."

Jerry Zolkowsi is a long-time reader and has been helping plants in Michigan monitor and measure energy use for a long time. His work for the Consumers Energy Business Energy Efficiency Programs often focuses on teaching clients to first measure and then figure out how to use less compressed air. We thank him for sending a great example of his work at a Hutchinson plant in his article, "Small Piston Air Motors Save Big Energy While Ensuring Safety."

Our last article is an example of the benefits of monitoring, even after one has purchased a new, high-quality, compressed air system. Veteran auditor Ron Marshall explores control gap issues, experienced with a relatively new system, in his article titled, "Air Compressor Control Lessons Learned at Metal Products Company."

Thank you for investing your time and efforts into ***Compressed Air Best Practices.***

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Compressed Air Industry News

Atlas Copco Celebrates 150 Year Anniversary

On February 21, 2023, the Atlas Copco Group celebrated their 150thanniversary. As part of the birthday celebrations, the Atlas Copco Executive Management Team rung the opening bell at the NASDAQ stock exchange. They were joined by employees from across the United States, all of which were celebrating having worked over 25 years with the Company. Also, to mark the occasion, the largest ever single check was donated from their Water for All organization, which is an employee led fund focused on clean drinking water, to the New York City based charity:water – the check was for $150,000.

Across 2023, the entire Atlas Copco Group will be celebrating the employees, customers, and suppliers who have been part of this journey. Compressed Air Best Practices® Magazine will be running an exclusive feature on some of the celebrations in the next edition. You can wish Atlas Copco a Happy Birthday on the following web page: www.atlascopco.com/birthdaymessages.

Parker Elects CEO and COO

Parker Hannifin Corporation, the global leader in motion and control technologies, announced its Board of Directors has elected Jennifer A. Parmentier as Chief Executive Officer and Andrew D. Ross as Chief Operating Officer, each effective January 1, 2023. Parker also announced its Board approved, effective January 1, 2023, an increase in the size of the Board from twelve to thirteen Directors and the appointment of Parmentier as a member of the Board.

Parmentier will succeed Thomas L. Williams as Chief Executive Officer and will report to the Board of Directors. Williams has served as Chief Executive Officer since 2015 and Chairman of the Board since 2016. To ensure a smooth transition of his responsibilities, Williams plans to continue as Executive Chairman from January 1, 2023 through December 31, 2023, at which time he intends to retire from Parker and the Board. Ross will succeed Parmentier as Chief Operating Officer, reporting to Lee Banks, who remains Vice Chairman and President.

"Jenny and Andy bring extensive experience across Parker's operating groups and regions, and each is a strong advocate for the power of The Win Strategy in driving our operations to record performance and growth," said Williams. "Together with Lee Banks and Todd Leombruno, our Executive Vice President and Chief Financial Officer, they will form the new Office of the Chief Executive and are the right team to lead Parker to achieve its FY27 performance targets.

Jennifer A. Parmentier, Chief Executive Officer, Parker Hannifin Corporation

"In coordination with the Board, I have been planning this transition for many years and believe this is the right time to step down from the CEO position. It has truly been an honor to lead this great company. As I reflect on my tenure as CEO, I am most grateful for the dedication and ownership of our team members globally. No matter where I am in the company, I have always felt your encouragement and full support. I'm proud of our work together to make Parker one of the safest places to work, our achievement of top quartile performance and the alignment of our entire organization around our purpose as a platform for growth, change and positive impact. Our new leadership team is backed by a deep, talented, and highly engaged global team. Parker has a very promising future ahead."

Commenting on the leadership transition, Lead Director James L. Wainscott, said,

Andrew D. Ross, Chief Operating Officer, Parker Hannifin Corporation

"Parker's Board of Directors takes a structured approach to senior leadership development and succession. Our process allows us to evaluate the performance, qualifications and cultural fit of key executives and benchmark them against other highly talented leaders. We are confident that both Jenny and Andy are the right leaders to continue the trend of very strong performance and transformational growth at Parker.

"Under Tom's leadership, Parker is a company transformed through both a significant improvement in its performance and a significant reshaping of its portfolio. Through strong cash generation and effective deployment of capital, Parker's portfolio of businesses has been strengthened and strategic acquisitions have returned value to shareholders in the form of higher margins, and a higher growth profile of businesses serving longer cycle end markets. Importantly, the company has also driven top quartile levels of engagement among team members across the world, inspired by the introduction of the Parker purpose statement, a focus on safety, and the deployment of high-performance teams. Tom's leadership legacy at Parker will last well beyond the years he spent as CEO."

Compressed Air Industry News

Parmentier became Chief Operating Officer in 2021 with responsibility for all of Parker's operating groups. Previously, she was Vice President and President – Motion Systems Group from 2019 to 2021 and Vice President and President – Engineered Materials Group from 2015 to 2019, where she was responsible for all financial and strategic aspects of the global operations of those operating groups. Prior to those roles, since joining Parker in 2008, she held a variety of operational roles including General Manager of the Sporlan Division in the Instrumentation Group, and General Manager of the Hose Products Division in the Fluid Connectors Group. Prior to joining Parker, Parmentier was Business Leader for Ingersoll Rand Trane Residential Systems and held operational leadership positions with Magna Corporation. Parmentier holds a Bachelor of Arts in Management from Webster University and an Executive MBA from Loyola Chicago Quinlan School of Business. She currently serves on the Board of Directors of Nordson Corporation.

"It's an exciting time to take on the leadership of Parker with its rich history of success," said Parmentier. "My goal will be to continue to build upon the tremendous work and momentum that Tom, Lee and our global team have set in motion. This will include an ongoing focus on the key principles of The Win Strategy, which will be the foundation for us to achieve our five-year goals. It's a great time to lead Parker to our next level of engagement, customer experience, growth and performance, all while our people and technologies make the world a better place."

Ross has extensive operational leadership experience across Parker's operating groups during his 24-year career with the company. He has been Vice President and President – Fluid Connectors Group since 2015. Previously, he was Vice President and President – Engineered Materials Group from 2012 to 2015. Prior to those roles, since joining Parker in 1998 as a Product Manager in the Engineered Materials Group, Ross has held various roles of progressing responsibility, including Vice President of Sales and Marketing and General Manager while in the Engineered Materials Group, and General Manager and Vice President of Operations in the Motion Systems Group.

"I'm very excited to partner with Jenny, Lee and Todd and the entire leadership team as we collaborate to help Parker achieve its goals," said Ross. "The operational improvements that Tom and Lee have established have led to historic levels of company performance. Yet we still see opportunities and our plan will be to continue striving for operational excellence across all of our businesses with the support of our engaged and talented global team members.

About Parker Hannifin

Parker Hannifin is a Fortune 250 global leader in motion and control technologies. For more than a century the company has been enabling engineering breakthroughs that lead to a better tomorrow. Parker has increased its annual dividend per share paid to shareholders for 66 consecutive fiscal years, among the top five longest-running dividend-increase records in the S&P 500 index. For more information, visit www.parker.com.

Kaeser Compressors Now Factory-Direct in Upstate New York

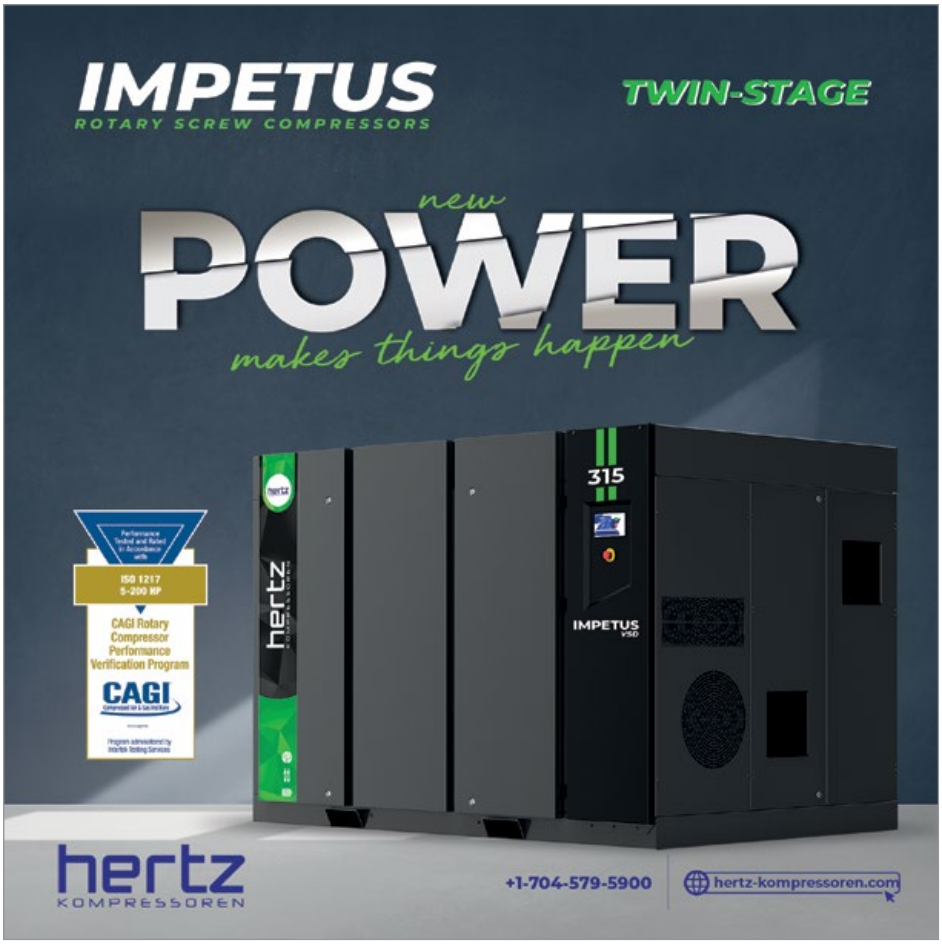
Kaeser Compressors, Inc. is opening locations in Syracuse and Buffalo to support its customers in the central and upstate regions of New York. Its trained and certified sales and service professionals are ready to meet all your compressed air, blower, and vacuum needs.

"We are very excited to directly support our existing customers in the region," said Jamison Vincent, Syracuse Branch Manager. "Plus, we look forward to expanding our customer base and providing reliable, energy-efficient air systems to a broad range of industrial, commercial and institutional users. Whether you need new equipment, routine maintenance, or troubleshooting, Kaeser is here to help." Factory-certified sales and service experts are now locally available to help assess each end user's specific needs and tailor solutions, whether as a complete compressed air system installation or a contractual solution. A native of upstate New York, Jamison is a graduate of Cornell University and a Marine Corps veteran. He previously served as Kaeser's Branch Manager in Atlanta.

About Kaeser Compressors, Inc.

Kaeser Compressors is a leader in reliable, energy efficient compressed air equipment and system design. We offer a complete line of superior quality industrial air compressors as well as dryers, filters, SmartPipe™, master controls, and other system accessories. Kaeser also offers blowers, vacuum pumps, and portable gasoline and diesel screw compressors. Our national service network provides installation, rentals, maintenance, repair, and system audits. Kaeser is an ENERGY STAR Partner. For more information, visit us.kaeser.com.

Kaeser opens office to serve both central and upstate New York including the regions of Buffalo, Rochester, Syracuse and Albany.



Compressed Air Industry News

Atlas Copco Acquires Canadian Medical Gas Service Provider

Atlas Copco has acquired the operating assets of MedCore Services Inc., a medical gas service provider in the Province of Ontario, Canada. MedCore Services Inc. was founded in 2010 and is based in Toronto, Canada. The company has 7 employees and had revenue of approximately 1.5 MCAD (around 10 MSEK*) in 2021. The company services piped medical gas equipment, including medical air systems, vacuum systems, and pipeline equipment. Customers are public healthcare and private clinics in Canada.

"MedCore Services Inc. is a respected company with an experienced service team," said Vagner Rego, Business Area President Compressor Technique. "The acquisition will enable us to further strengthen our position as a leading service supplier of medical gas solutions in this key region in Canada." The purchase price is not disclosed. The acquired business will become part of the Medical Gas Solutions Division within the Compressor Technique Business Area.

About Atlas Copco Group

Great ideas accelerate innovation. At Atlas Copco we have been turning industrial ideas into business-critical benefits since 1873. By listening to our customers and knowing their needs, we deliver value and innovate with the future in mind. In 2021, Atlas Copco had revenues of BSEK 111 and at year end about 43,000 employees. For more information, visit www.atlascopcogroup.com.

Case Controls and iZ Systems Merge

Case Controls and iZ Systems, world leaders in industrial compressed air, vacuum, and cooling water automation and controls technology, plant demand and supply side auditing, system design, and energy management solutions, are pleased to announce the merger of the two companies.

CASE iZ
GUARANTEED COMPRESSED AIR SOLUTIONS

The new company, Case iZ, combines the individual strengths of each company's more than 30 years of experience in reducing energy consumption and improving production efficiencies and product quality, by stabilizing and controlling pressure and flow in plant utility systems.

Case iZ engineers design, build, and program state of the art automation and control solutions on the Rockwell Automation Allen-Bradley platforms. Our methods and capabilities of managing and controlling all sizes, makes, and types of compressors, air treatment, vacuum pumps, and cooling water systems, allows Case iZ to provide our clients comprehensive, turn-key, guaranteed return on investment projects.

The Case iZ solution utilizes IoT technology for data collection and analysis, monitoring and displaying real time system parameters and energy status. An on-line dashboard, along with data and trending screens, provide plant operators live information to better manage their overall plant systems.

Please contact Case iZ for a free initial assessment of your plant's potential for energy reduction and production improvement opportunities at 844-448-9797 or www.caseiz.com.

Universal Compressed Air Partners with ENERGY STAR®

UCA announced it has been accepted to the U.S. Environmental Protection Agency's (EPA) ENERGY STAR program as an ENERGY STAR partner. Through its voluntary partnership with the ENERGY STAR Program, UCA will work to improve energy efficiency and fight climate change by helping its commercial building customers implement proven energy-saving strategies designed to enhance the organization's financial health and preserve the environment for future generations.

"UCA is pleased to become an ENERGY STAR partner," said Executive Vice President & COO, Rick Kowey. "Through this partnership, we will demonstrate our commitment to environmental stewardship by delivering energy performance improvements and financial value to our customers."

In partnership with ENERGY STAR, UCA will help its clients to embed energy management programs, assist compressed air users to achieve ENERGY STAR certification, take action to realize cost savings through energy efficiency projects and increase an organization's value, lower risk, and deliver other business benefits.

ENERGY STAR PARTNER

UCA has been accepted as an ENERGY STAR partner.

Compressed Air Industry News

UCA will also encourage businesses to join ENERGY STAR, ensure clients can quantify and maintain savings, support clients with identifying and purchasing ENERGY STAR products and encourage corporate staff to learn about the benefits of energy efficiency.

"Improving the energy efficiency of our nation's buildings is critical to protecting our environment," said Cindy Jacobs, Chief of the ENERGY STAR Commercial & Industrial Branch. "From the boiler room to the board room, ENERGY STAR partners are leading the way by making the buildings where we work, play, and learn more efficient."

Yannick Koch, Norbert Strack and Sascha Niederhagen form the new management team at BEKO Technologies (left to right).

About Universal Compressed Air

UCA is a privately-owned and thriving high-technology business in Pennsylvania's Lehigh Valley focused on compressed air systems for industry. UCA brings decades of Industrial Gas expertise to Compressed Air Supply Systems (CAS). Our PIPELINE AIR™ CAS are designed, engineered, built, operated, and maintained to deliver compressed air as a utility and, in every case, an efficient, reliable, and application-tailored solution to maximize savings and optimize the end user's success. For more information about UCA, visit www.UCAair.com.

BEKO Technologies Expands Management

The manufacturer BEKO Technologies, which specializes in compressed air treatment, is expanding the current management board, consisting of the leadership team with Yannick Koch and Norbert Strack. Effective January 1, 2023, Sascha Niederhagen will be the third Co-CEO. Niederhagen is responsible for sales, marketing and product management, and also acts as chairman of the management board.

Sascha Niederhagen is a proven leader and has extensive international sales experience. Most recently, he served as Chief Sales Officer, Managing Director and Member of the Management Board at Bürkert Fluid Control Systems.

BEKO Technologies will drive forward the digital transformation with Sascha Niederhagen. The new Co-CEO sees the definition of cross-company, customer-centric processes as a prerequisite for digitization in sales. "The key to success is designing the best possible, process-based and absolutely customer-focused customer experience," said Sascha Niederhagen. "I am looking forward to working closely with my two fellow managing directors, the entire team and the exceptionally good corporate culture. Together with all BEKO Technologies team members, we will continue to shape the company successfully and future-proof, and in the long term develop it into an even more networked, global partner for our customers."

For more information, visit www.beko-technologies.com.

Donaldson Company Announces New Leadership Appointments

Donaldson Company, Inc. announced new leadership appointments as part of an ongoing broader organizational redesign aimed at better-positioning the company to serve its end market customers. Once completed, the redesign is expected to allow the company to more efficiently direct resources to strengthen commercial execution.

"Donaldson has successfully built a diverse portfolio of businesses with different value propositions for each market we serve," said Tod Carpenter, chairman, president, and chief executive officer. "This redesign will enhance our ability to serve our customers by aligning our business models, resources and cost structure to the specific needs of each end market, while creating greater internal ownership and accountability for short- and long-term performance."

The company is moving away from its previous matrixed organizational structure, which included a regional focus. As a result, Donaldson announced the following appointments effective November 1, 2022:

- Guillermo Briseño, president, Industrial Solutions
- Andrew C. Dahlgren, president, Life Sciences and Special Applications
- Bart Driesen, president, Mobile Equipment Solutions Aftermarket
- Richard B. Lewis, president, Mobile Equipment Solutions
- Thomas R. Scalf, president, Enterprise Operations and Supply Chain
- Keith Bechtum, vice president, Mobile Equipment Solutions OEM Sales
- Mauricio Goes, vice president, Industrial Solutions Aftermarket and Service
- Angela Zurick, vice president, Mobile Equipment Solutions North America Aftermarket

With the new structure, Jeffrey E. Spethmann, SVP, Industrial Products, and Wim J.V. Vermeersch, VP, EMEA, will depart Donaldson after assisting with the transition. "I extend sincere thanks to Jeff and Wim for their significant contributions and dedication to our customers, our company and our employees, especially those they mentored and developed over their tenures," Carpenter said. "They are both strong leaders and I wish them all the best in the future."

About Donaldson Company, Inc.

Founded in 1915, Donaldson is a global leader in technology-led filtration products and solutions, serving a broad range of industries and advanced markets. Our diverse, skilled employees at over 140 locations on six continents partner with customers – from small business owners to the world's biggest OEM brands – to solve complex filtration challenges. Discover how Donaldson is Advancing Filtration for a Cleaner World at www.Donaldson.com.

Mattei Rotary Vane Technology Advancing Efficiency and Durability

By Roderick Smith, Compressed Air Best Practices® Magazine

A modern installation of Mattei rotary vane air compressors.

➤ Compressed Air Best Practices® Magazine interviewed Mr. Bill Kennedy, Global Marketing Manager, Mattei Compressors.

Good morning! Please describe your role at Mattei Compressors.

Good morning. I joined Mattei Compressors in 2008 and have held a variety of product management, marketing and sales management roles. My current responsibility is as Global Marketing Manager. Our marketing team supports all five divisions of the Mattei Group as well as all subsidiaries. I also support the U.S. sales team, led by National Sales Manager Justo Valenzuela, with air compressor energy efficiency comparisons for specific projects.

Can you describe the leadership and structure of the Mattei Group?

Absolutely. The Mattei Group is led by Chief Executive Officer Giulio Contaldi and by Chief Financial Officer Silvia Contaldi. The Mattei Group is organized internationally into these main divisions.

1. The Industrial Division provides stationary fixed and variable speed rotary vane air compressors from 2 to 275 hp (1.5 to 200 kW) to the manufacturing and process industries. We sell exclusively through an international network of authorized air compressor distributors to end users.
2. The Rail and Transportation Division provides long-lasting compressors to the OEM transport industries including train, bus, and electric vehicle manufacturers.
3. The OEM Air Compressor Division provides air compressor packages to

specialized OEM applications. A hallmark of our firm is a compact, lightweight unitized package incorporating all components in the system.

4. The OEM Gas Compressor Division focuses on biogas and natural gas applications. A major market is feeding fuel to microturbines.

5. The Aluminum Smelting Air Compressor Division; Within the Americas, the province of Quebec represents the lion's share of the aluminum smelting global market. These are custom 100 horsepower rotary vane air compressors whose inherent durability is able to withstand a very hostile application with high ambient temperatures, 24/7 year-round operation and a harsh environment.

6. The Mattei On-Vehicle Energy (MOVE) Solutions Division provides precision-outfitting of service vans and trucks up to 30 tons in size. Every energy source a truck needs to be self-sufficient including air compressors, power generators and pressure washers. This eliminates the need, for example, for tow-behind portable air compressors.

Pictured are Chief Executive Officer Giulio Contaldi and Chief Financial Officer Silvia Contaldi from Ing. Enea Mattei SpA.

Didn't Mattei Compressors recently celebrate a 100-year anniversary? Can you provide a brief history?

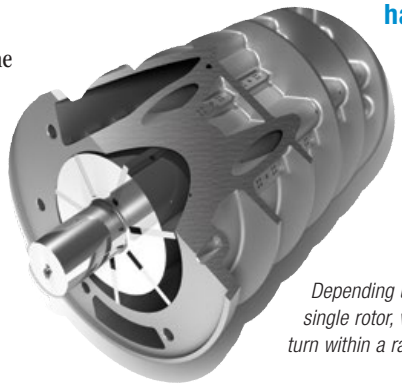
You are right! We were proud to celebrate, in 2019, the 100-year Centennial of Mattei Compressors. Founder Enea Mattei began the business by manufacturing large, water-

Mattei Rotary Vane Technology Advancing Efficiency and Durability

cooled reciprocating air compressors. In the 1950's, he saw the potential of and began to develop rotary vane technology. His goal was to create a product that had the durability and longevity of those large recips while reducing the requirements for cooling water and the expense of minor valve jobs and major piston ring and bearing overhauls, to further reduce lifecycle costs. The business has continued to be privately held since Mr Mattei sold the business to Giulio Contaldi Sr. in 1958.

Much has changed over the decades since the first rotary vane compressors were engineered and marketed. Raw lamb's wool air/oil separators gave way to precision engineered borosilicate material that was made into filter cartridges that have improved over the decades to be much more efficient in coalescing oil while retaining low pressure drop. Fossil derived motor oil and transmission fluids gave way to synthetic lubricants engineered from a variety of base stocks that provide superior lubricity and longevity while reducing friction and lowering input power requirement.

Where does Mattei have operations?



Depending upon the model, the new Mattei single rotor, variable speed, rotary vane airends turn within a range of 800 to 1800 rpm.

Mattei is headquartered in Vimodrone, in the province of Milan, Italy. Air compressor manufacturing and

A 100 horsepower Mattei ultra-performance fixed speed rotary vane air compressor.

package assembly is done in Vimodrone, Verdello-Zingonia (province of Bergamo), Baltimore (U.S.), Woking (England). Mattei exports to over 100 countries and manufactures over 6500 air compressors per year. We have 17 global patents and subsidiaries in the U.S., France, U.K., China, Germany and sales representative offices in Spain and Singapore.

Please describe your U.S. operations.

Mattei Compressors, Inc. is headquartered outside Baltimore in Randallstown, Maryland. Established in 1985, Mattei Compressors supports the America's with inventory warehousing and custom packaging/assembly capabilities. Our team of Regional Managers across the U.S. support OEMs and air compressor distributors. Over the past ten years the business in the U.S. has tripled, driven by the launch of 50-275 horsepower, sound attenuated, fixed and variable speed air compressors. The attention given to energy efficiency of these product lines has driven a strong level of air compressor distributor support.

I remember seeing many rotary vane air compressors in the furniture and woodworking plants of Spain, near Alicante. Don't rotary vane air compressors have a history of reliability and extreme durability?

Yes, they are known for their reliability and durability – even when the coolers are obstructed with wood chips! Mr. Mattei's, single-rotor vane compressor was engineered using the same materials of construction for the rotor, the stator and the vanes or blades. This compatibility is what drove the vision to eliminate wear from the compression process in making his compressors virtually wear-free. Wear is the result of the softer of two dissimilar metals being abraded when rubbed together. In using compatible metal for the rotor, stator and blades, wear is eliminated. Instead, there is a microscopic transfer of material that mates the adjacent surfaces in creating a better seal that reduces friction and improves overall system efficiency over time. We call this process "Vane Gain." And while inherently efficient at startup or "zero hours", the energy efficiency rating of the vane compressor uniquely continues to get even better over time through normal operation.

Can you describe the positive displacement air compression process in a rotary vane?

The architecture of vane technology makes the air compression process quite unique. Atmospheric air is drawn into the machine through an oversized air filter and inlet valve that minimizes pressure drop. It enters into a compression cell created between each pair of blades and the end covers. As such, the pressure within each compression cell is equal from one end of the pump to the other end. As the pump rotates, the volume within each compression cell decreases and the pressure rises. One-half a rotation takes each cell pressure from atmosphere to the final discharge pressure.

Mattei Rotary Vane Technology Advancing Efficiency and Durability

Most positive displacement air compressors use a combination of roller bearings throughout the compression process to offset the radial and axial forces in maintaining the tolerances engineered into the design. Axial forces result in bearing wear due to the presence and absence of axial forces during the load (compression) phase and unload (not compressing) phase as directed by the upper and lower set points of a pressure switch.

A 125 horsepower Mattei variable speed rotary vane air compressor.

What is the importance of what you call the "bearing-less" vane design?

By design, a vane air compressor is perfectly balanced. This is a significant advantage for the end user as it is the key to getting the lowest lifecycle costs in the industry. As with the other positive displacement air compressors, the vane compressor must contend with radial forces. Unlike the others, vane technology is 100% devoid of axial thrust forces. From suction to discharge, the pressure is always perfectly balanced as it is equal across the length of the pump. Thus, a Mattei vane air compressor rotor doesn't have to contend with thrust forces, so the compressor shaft simply rotates upon a microns thick oil film within a pair of bushes crafted from a proprietary metallic blend that never need maintenance or replacement as there is no wear. In fact, because the compressor shaft rides on an oil film, the original tolerances are a constant that is restored simply and automatically with each oil change. Presently, we are testing PTFE blended bushes that show great promise in further advancing the energy efficiency level of our air and gas compressors.

Is there a recent technological advancement with Mattei rotary vanes you'd like to review?

Absolutely. Today's Mattei remains clearly focused on continuously improving the energy efficiency and durability of our proprietary vane technology with the goal of building the most energy efficient air compressors money can buy. In 2021, Mattei patented XTREME Injection Technology® which significantly raised the energy efficiency bar where deployed.

XTREME Injection Technology® begins with the use of fluid atomization nozzles that create cone shaped clouds of super fine lubricant fog able to develop thanks to the open compression cells extending throughout the pump and across its axis. These aerosolized droplets provide significantly more surface area than traditional oil injection systems to allow for a much more efficient method of heat transfer to quickly capture the heat from the compression process and stabilize the compressed air at an ideal temperature in real time. This results in high Isentropic Efficiency ratings and a significant reduction in input energy requirements to arrive at some of the best specific power rankings in the industry.

For the initial launch phase, we have deployed this technology on 75-125 horsepower, fixed and variable speed, rotary vane air compressors. Results have been excellent with regard to reliability and efficiency. We are very excited that our 6-pole motor driven RVX UP Series can achieve 2-stage efficiency levels with our proprietary single stage design.

I've noticed you have a unique approach to the conversation about air compressor lifecycle costs.

Yes, we emphasize the low lifecycle costs of our durable rotary vane technology – and

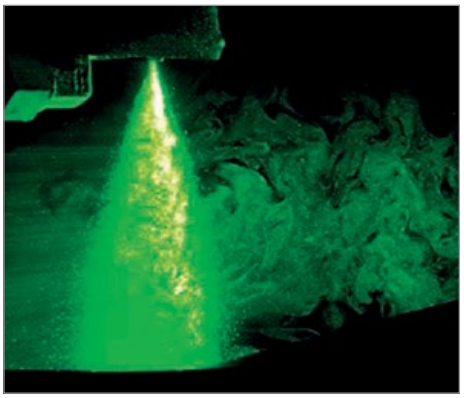


Image of an atomized lubricant cone used in the patented XTREME Injection Technology®.

attempt to increase the awareness of the costs of airend overhauls common with other positive displacement air compressor technologies. Nobody wants to pay more for a product than they must. The value of many items is determined by the purchase price. Not so with air compressors. Yes, the purchase price is important but that only represents the "entry fee" to having a compressor. A good rule-of-thumb states that over the life of an air compressor, your lifecycle costs totaling 100% with normal maintenance, are divided into three (3) categories.

1. the purchase price (10%)
2. the cost of electricity to power and run the compressor (80%)
3. the cost for basic maintenance for the air compressor (10%)

Where vane technology differs in Lifecycle cost conversations is reflected in the elimination of airend overhauls which can easily exceed 50% of the initial purchase price of competing compression technologies.

So, while the purchase price is important, the big money is deferred through the high cost of electricity and the specter of needing to overhaul the airend as a result of axial bearing wear. What you can control is defining the electric cost of running the air compressors being offered by performing your due diligence during the purchasing phase. Consider this: if the electricity costs 8x what you paid to purchase the compressor, and you can reduce that value by 20% or more, the compressor is virtually free as the energy savings provide a return-on-investment that exceeds the purchase price. Now, if you eliminate the need to ever have to overhaul the airend you gain a massive financial and long-term reliability advantage.

Thank you for your time. BP

For more information about the Mattei Group visit https://www.matteigroup.com/ or contact Bill Kennedy at bill.kennedy@matteigroup.com

To read similar ***Air Compressor Technology*** articles, visit https://airbestpractices.com/technology/air-compressors

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Improving Sustainability Through Compressed Air and Utilities Monitoring

By Dr. Michael Britzger, Senior Manager, IIoT Engineering & Innovation, and Nils Beckmann, Product Marketing Manager IIoT Integration for EMERSON Machine Automation

Utilities monitoring paired with machine learning models can reliably predict anomalies, prompting action that can prevent waste and optimize resource use.

Many of the decisions that industrial and discrete manufacturing companies make every day determine the sustainability of their operations. Resources like compressed air, electricity, gas, water and steam power much of the production equipment that's essential to a company's success. How they use that equipment, as well as how and when they choose to maintain it, affects compressed air and utilities consumption – and emissions levels.

The industrial sector is responsible for 33% of total U.S. energy consumption, and it's estimated that industrial manufacturers use more than 18.2 billion gallons of water from direct water withdrawals each day and about 12% of the public water supply. With today's ambitious net-zero and water conservation goals, it's in the best interest of the company and the environment to make decisions that optimize production and resource use.

Several factors influence the effectiveness of a company's decision-making process to reliably improve sustainability. What informs decisions? How long do they take to make? Are they reactive, responding to an outcome after it's happened, or are they proactive, taking action to bring about or prevent an outcome?

A company's ability to consistently make smart decisions that optimize resource use and reduce emissions while improving overall equipment effectiveness (OEE) often depends on the technology integrated throughout its floor.

The digital transformation of factory settings has equipped production lines with a variety of sensors that allow for continuous monitoring and provide data about compressed air, water, steam, gases, electricity and other critical utilities, as well as root cause analytics. By using this data and applying supervised and unsupervised machine learning algorithms, the generation and aggregation of data allow for not only descriptive and diagnostic analytics but the prediction of events like leakage and failures. (Figure 1)

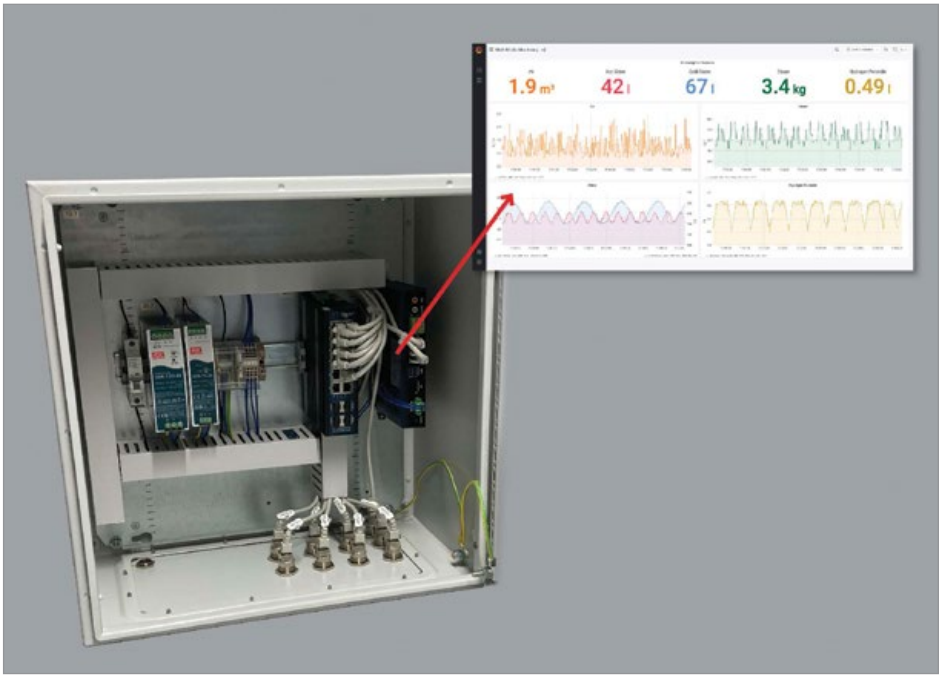

Figure 1: Emerson's multimedia monitoring solutions provide data about compressed air, water, steam, gases, electricity and other critical utilities leakages and translate it into valuable insights that can optimize productivity and prevent or reduce unplanned downtime. (Image courtesy of Emerson)

Through a combination of continuous monitoring and machine learning, manufacturers can receive the insights and clarity necessary to make quick, informed decisions that can reliably optimize resource use and improve sustainability as well as productivity.

The Power of Prediction

Those familiar with digital transformation may be aware of the benefits that real-time monitoring and measurement provide, but predictive machine learning models may be new to them. While both models help provide valuable insights to inform decisions that can reduce costs and optimize processes, their results are of different degrees. Real-time monitoring informs users of an incident and enables them to react just after it happens. It minimizes the effects of an issue. Prediction models, on the other hand, can prevent issues altogether by providing information about what is *going to happen*[1]. Instead of being notified shortly after the fact, end users receive information about an issue that will or may occur very soon. This empowers users to optimize their operations and move from reactive to proactive operational processes.

While monitoring solutions offer real-time insights, it's fair to say that machine learning model predictions are future-time insights. We've seen from countless books and movies that knowing what will happen before it does happen is incredibly valuable. A plant that can precisely control operations informed by predictive machine learning models has the potential to achieve perpetual uptime, avoid quality issues and possibly prevent injuries.

In the ideally connected world, smart systems report failures before they happen and take the necessary corresponding actions. Imagine the process: the system predicts a leak and its location, then orders the component forecasted to fail and schedules maintenance in a regular time slot, all before a lot of air is lost. No unplanned downtime, no unnecessary energy consumption. Predictive machine learning models can make significantly optimized operations like this a reality.

Improving Sustainability Through Compressed Air and Utilities Monitoring

Leading digital transformation solution providers are successfully developing accurate machine learning models for manufacturers to deploy. For example, engineers at Emerson have developed a machine learning-driven model that predicts the behavior of a pneumatics system. When minor deviations from the expected behavior occur, the model can detect the corresponding anomalies, such as leaks, and pinpoint their location within the system.

Compressed air production makes up 20% to 30% of overall energy costs across discrete and hybrid industries. However, a significant portion of this cost is unnecessary, since nearly a third to a fourth of industrial compressed

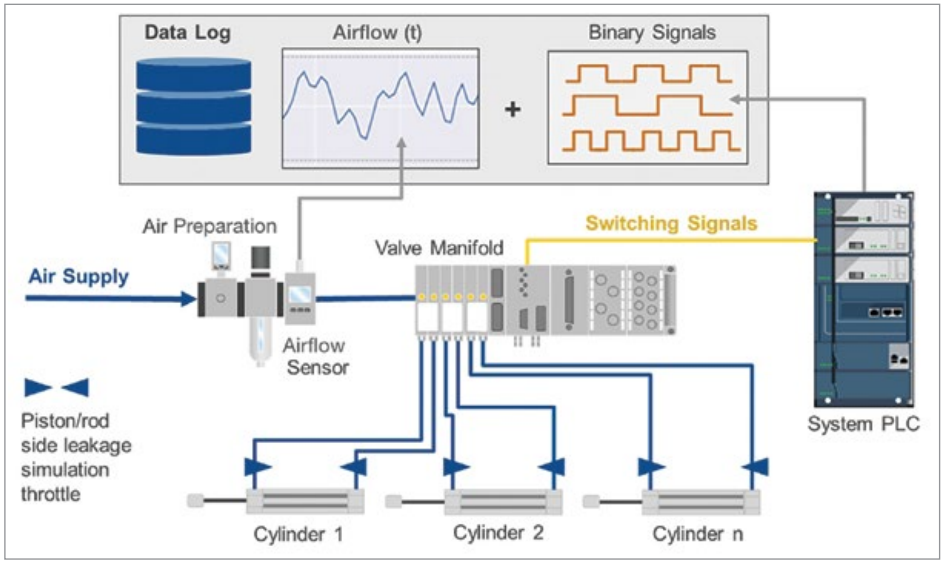

Figure 2: This diagram shows a typical, digitally transformed pneumatic system: an airflow sensor measures compressed air and stores collected data in a database, which sends signals to a PLC to switch corresponding valves on or off. (Image courtesy of Emerson)

air consumption is waste caused by leaks. At the same time, the growing complexity of industrial pneumatic systems can make it harder to identify the compromised subsegment or component where leaks occur. By accurately predicting the presence and location of such anomalies, machine learning models have the potential to prevent leaks altogether, reducing the amount of energy consumed – not to mention maintenance costs and unplanned downtime – and significantly improving overall system efficiency and sustainability.

How to Train a Machine Learning Model

The nature of typical industrial applications presents several challenges for a pneumatic learning model. Modern industrial machines and the environments where they operate can differ greatly. Temperatures and the dynamic viscosity of air itself change from plant to plant, preventing straightforward, linear models. The configuration and pneumatic architecture of each system vary from a few to several hundred components, and leaks are local events that models must assign to components.

Figure 3: Much more than a flow meter, the AVENTICS™ AF2 Flow Sensor continuously monitors compressed airflow, measures 8 performance parameters, including energy, and helps detect leaks in pneumatic systems. (Image courtesy of Emerson)

In addition to this variation, many applications have a limited amount of training data available. Although the digital transformation of industrial equipment offers an extensive range of sensor and process data, little historical data exists because most machines have few, if any, sensors.

Luckily, the inclusion of even a few sensors provides enough reference behavior to train a machine model. It should be noted that this is basically the core mindset of digital transformation – most of the time, it's not about inventing new algorithms or technology but instead understanding the environment and application and applying existing technological "bricks" that add value. For pneumatics, the most relevant data are the central flow rate of the compressed air and the binary control signals of the pneumatic valves, which are available in the control data from the system's PLC.

What do the central flow rate and binary control signals tell a learning model about the presence or location of a leak? The flow rate itself doesn't reveal anything except the general amount of consumed air. But it does provide a reference for the ideal workflow that the model should expect. That makes it critical that the central flow rate be measured with no actual or potential leaks

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present. When airflow deviates from this ideal workflow, it signals a potential leak. Correlating that deviation with the binary signals of the valve manifold will then indicate exactly where the anomaly occurs.

In Emerson's application use case, this historical data is gathered by a smart sensor and a PLC. The sensor is integrated with an air preparation unit that supplies compressed air to the pneumatic system. As the compressed air moves through, the sensor measures the overall airflow of the system and stores historical data to a database. The system PLC switches the corresponding valves of a valve manifold that is connected to the piston and rod sides of a series

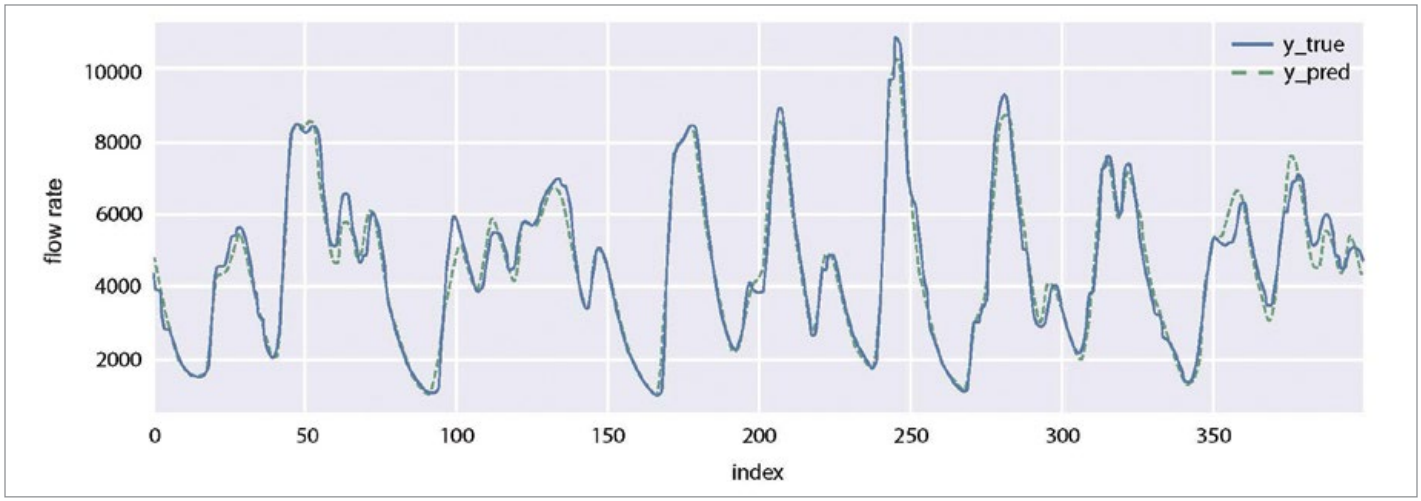

Figure 4: Emerson's IIoT engineers trained this prediction model, which achieved an overall airflow prediction accuracy of the mean absolute percentage error of below 7%. (Image courtesy of Emerson)

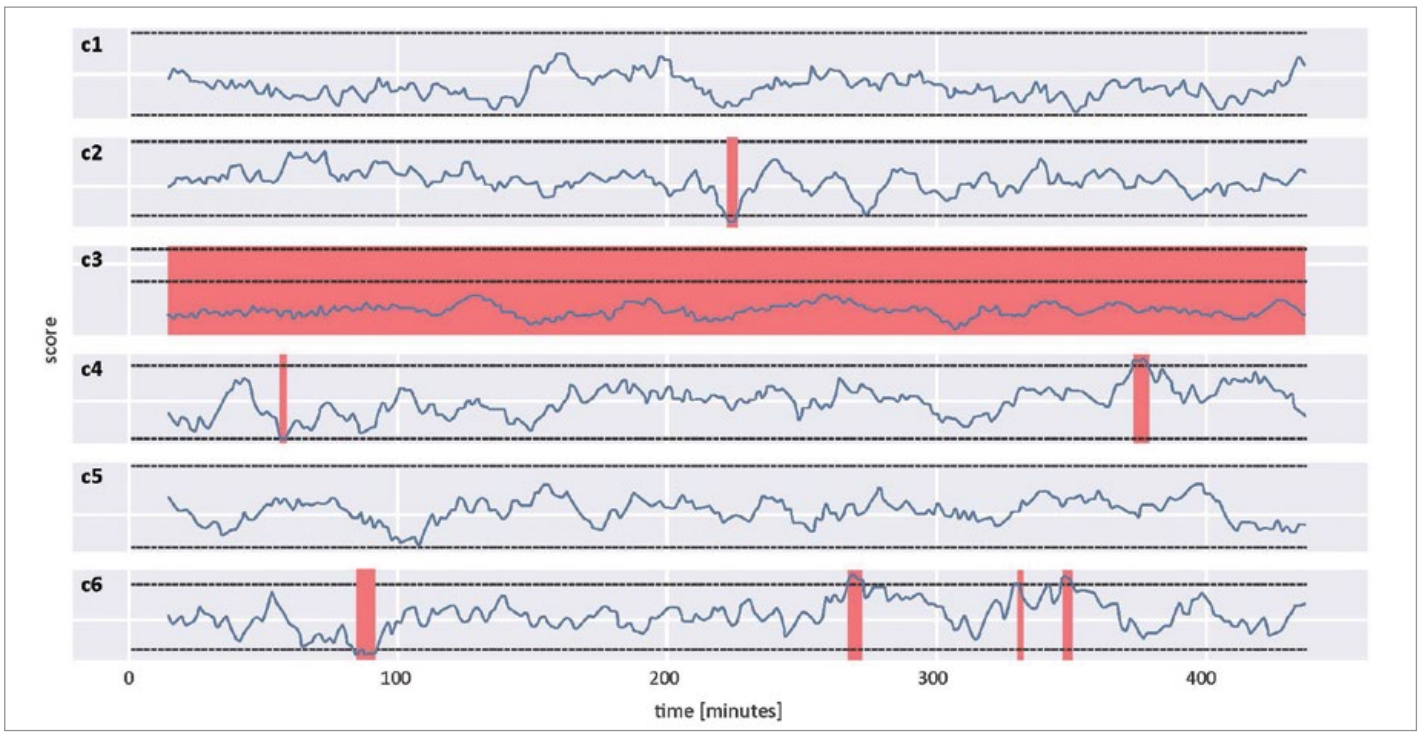

Figure 5: This graph demonstrates how the score value decreased and differed from the reference score when leakage was induced at the piston input side of cylinder 3. (Image courtesy of Emerson)

of cylinders. The binary switching signals are then stored in the same database. (Figures 2-3)

In addition to historical data, a successful dynamic airflow prediction model requires validation data. To create validation data, leakage is induced via a throttle at each input supply side of every cylinder. Thus, artificial leaks are generated and the corresponding data recorded helps to validate and improve the existing algorithms before applying the solutions to an existing field application.

The Real-World Value of Accurate Forecasting

Meanwhile, models have successfully learned how to predict airflow in industrial pneumatic systems. For instance, Emerson's machine learning model achieved a prediction accuracy of over 90%, forecasting significant anomalies and leakages, as well as indicating their location within the industrial machine. Even more, it determined a statistically significant forecast when creeping leakages affected the overall system behavior.

The system this model learned how to predict was an installed system without supervised learning or similar training data. The training data used included the overall airflow measurement without leakage, cross-correlated with the corresponding switching signals that made the system dynamics accessible. Based on the no-leakage data, the trained prediction model achieved an overall airflow prediction accuracy of the mean absolute percentage error of below 7%. (Figure 4)

While the prediction model for the airflow was the first step, the more complex, second step was to understand the behavior of the system using the corresponding valve switching signals to predict creeping leakage. Significant anomalies, like a broken pneumatics tube, are not very difficult to identify and locate because they usually make noise or stop the production process. A creeping leakage occurs rather silently and isn't easily detected. These leaks can go unnoticed for long periods of time, subtly slowing cycle time, negatively impacting product quality and increasing energy costs. By identifying creeping leakage, machine learning models can help improve system efficiency in the long term.

The airflow prediction model that was generated and continuously improved served as a reference of the pneumatics system, including the empirical null distribution of each cylinder side serving as the cylinder-specific reference score. If a leak occurred, the measured score would have a value that was bigger or smaller than the reference score. Using this deviation, the faulty cylinder or valve and corresponding piston or rod side of the component could be identified.

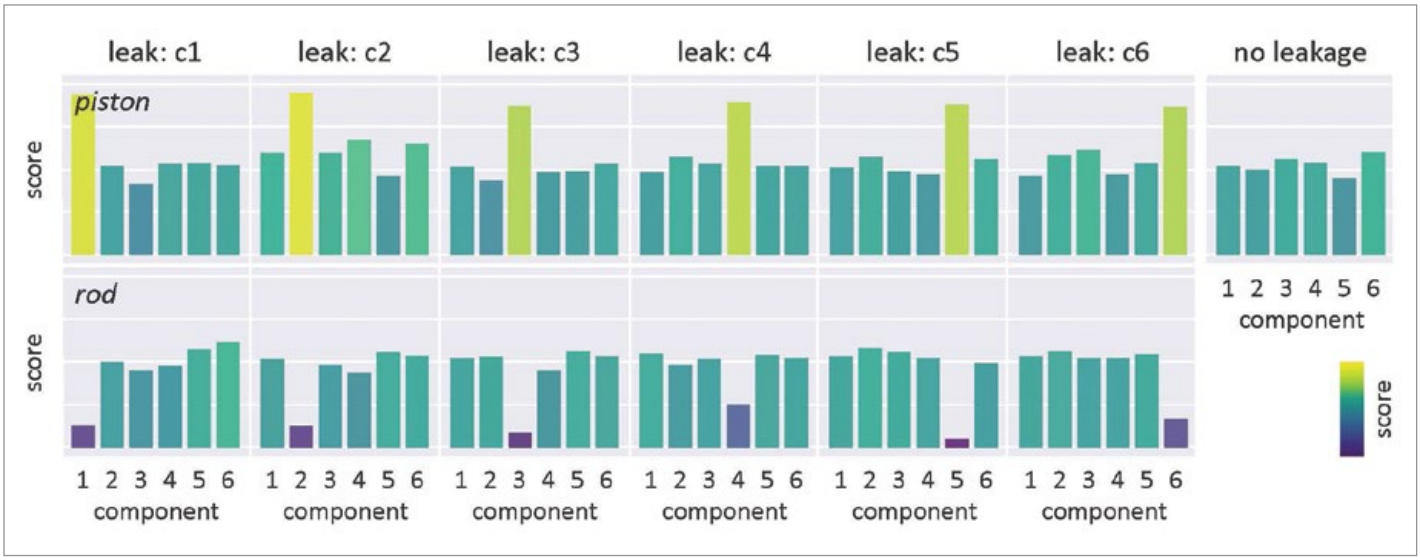

Figure 6: In this 12-run example of a prediction model, it's clear to see where leakages were induced on both piston and rod sides, as those leakage score values differ from the reference data. (Image courtesy of Emerson)

Improving Sustainability Through Compressed Air and Utilities Monitoring

For significance testing, leakages were manually induced for the piston and rod sides of each cylinder. This graph shows that when leakage was induced at the piston input side of cylinder 3, the measured score value decreased and significantly deviated from the reference score. (Figure 5)

The full significance of the prediction model is demonstrated in this graph. (Figure 6) Leakages were induced in 12 runs for each cylinder on both piston and rod sides, and the score values significantly deviated from the no-leakage reference data, pointing to the exact location of the induced leaks.

Smarter Operations for a More Sustainable Future

AI-based condition monitoring and prediction can significantly improve a manufacturer's decision-making process and optimize resource use and sustainability while improving OEE. And by reducing costs and increasing uptime, they can quickly pay for themselves.

As these sophisticated analytics tools become more and more accessible via standardized tool sets and libraries, organizations of all sizes can scale them for their sustainability goals and begin making decisions informed by what is really happening in their processes and machines in real – and future – time. By integrating machine learning models, their operations become proactive, not reactive, and manufacturers can achieve unprecedented control over their environmental impact today and tomorrow. BP

Endnotes

1. Based on the historian training data and the model.

About the Authors

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Nils Beckmann is Product Marketing Manager IIoT Integration for Fluid Control & Pneumatics at Emerson. In his role, he works in the IIoT environment, including the networking and analysis of machines and plants in the industrial environment. He has a master's degree in applied software science.

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Small Piston Air Motors Save Big Energy While Ensuring Safety

By Jerry Zolkowski, Industrial Energy Management Principal Engineer, Consumers Energy Business Energy Efficiency Programs

➤ Air Motors are Intrinsically Safe

While electric motors are typically used as an efficient source for motion, there are some applications using small (less than 2 hp) air motors. Paint mixing and agitation is a common application. The intrinsically safe nature of the motor makes it a safe and inexpensive choice for volatile mixes. Due to the high cost and inefficiencies associated with compressed air, a common efficiency recommendation is to replace the air mixers with intrinsically safe electric mixers. But it is hard to convince plants to act. Aside from the cost of the electric mixer, there is also the cost to run electric service to the mixer. Considering the upfront cost, effort, and risk, plants generally do not make the efficiency switch to electric.

These air motors are typically vane motors. Sliding vanes form a seal between the shaft and the wall, and the chamber size expands as the shaft rotates around providing the motive force. An alternative is the piston air

motor. With a piston motor, air expands to move a piston which turns a shaft much like a combustion engine. A typical piston motor will have three (3) to six (6) radial pistons. Vane motors can run at much higher speeds (2000 rpm and up), but piston motors tend to turn much slower – less than 1000 rpm. For slower speed applications, vane motors are mated with a gear reducer and called a gearmotor. The gearmotor can produce the higher torque and slower speed needed for some applications, but the gear reducer can add some drivetrain loss. While a piston air motor may not be able to replace a vane motor where high speed is needed, it can be a good choice for high torque/low speed applications.

The Hutchinson plant in Ithaca, Michigan (photo credit: Dave Brushaber).

Comparing the Efficiency of Vane and Piston Air Motors

Power is torque and speed together. A literature survey of four vane motor suppliers covering 10 vane motors showed the flow per horsepower at maximum rating was 46.13 cfm/hp. Gearmotors were not included, but they would be expected to be slightly worse due to the drive loss. Five suppliers of 12 piston motors at maximum rating provided an average of 28 cfm/hp. All motors were under 2 hp, and the pressure ratings were 90-100 psi. Larger vane motors appear to have better efficiency. Fewer larger vane motors can make a better economic case to switch completely to electric – so the biggest impact is upgrading multiple small units where running electric service is a hurdle due to safety or cost.

The piston air motor uses less air per horsepower. To translate this into savings

Small Piston Air Motors Save Big Energy While Ensuring Safety

consider the full load ratings. The improvement to use the piston air motor is the difference between the two averages or 18.13 cfm/hp. Applying a compressor efficiency of 20 kW/100 cfm (or 0.2 kW/cfm) provides a savings of 3.63 kW/hp. This is summarized below:

Average vane air motor efficiency	46.13	cfm/hp
Average piston air motor efficiency	28.00	cfm/hp
Improvement	18.13	cfm/hp
Compressor efficiency	0.2	kW/cfm
Demand savings	3.63	kW per hp

The demand savings is multiplied by the annual run hours to obtain the energy savings in kWh:

Energy savings for annual hours

2000	7,253	kWh per hp
4000	14,506	kWh per hp
600	21,759	kWh per hp

One of the useful features of air motors is the ease of setting the speed with a flow control knob. Air motors often run below their full rating. If only 2/3 of the savings are realized due to running at reduced capacity, the annual savings values become the following:

However, these are often speed reduced. Assume 2/3 savings.

2000	4,835	kWh per hp
4000	9,67	kWh per hp
6000	14,506	kWh per hp

A new piston air motor used with an agitator for safe volatile paint mixing at the Hutchinson plant in Ithaca, Michigan.

With an energy cost of $0.10/kWh, the annual savings land in the $500-$1500 range per horsepower annually. Installation cost should be low since it is a matter of replacing the air motor without running electric service. However, piston air motors can be much more expensive than vane motors. A small piston air motor can cost about $2,000 where a small vane motor may cost $300 and a gearmotor under $1000. If there is considerable run time, the piston air motor is worth the extra expense.

A rotary screw air compressor installed at the plant.

Hutchinson Aerospace and Industry

Hutchinson is a division of Total. The plant in Ithaca, Michigan covers 60,000 ft^2 and makes antivibration mounts for several different

Small Piston Air Motors Save Big Energy While Ensuring Safety

A refrigerated compressed air dryer installed at the plant.

markets including heavy truck and industrial. Volatile solutions are kept in suspension throughout the plant in 5-gallon paint pots and drums. The 21 agitators were originally a paint mixer with a 1-hp vane gearmotor. The 20:1 gear reduction provided a torque increase and speed reduction from 2400 rpm down to 120 rpm. There was no pressure reduction from the 105 psi header pressure. Performance curves showed the air consumption was 26 cfm.

The plant converted to a ½ hp direct drive piston air motor from Circle Dynamics, the Doyle 619-4T. This motor draws 9.75 cfm at 600 rpm and 1.38 cfm at 200 rpm. At the 125 rpm operating speed the motors are expected to draw 0.6 cfm. This provided a savings of up to 25 cfm per agitator.

Most of the agitators run 24/7, and this is by far the largest compressed air load in the plant. Assuming an average agitator has 6000 hours of run time and compressor efficiency is 0.2 kW/cfm, the annual savings would be 30,000 kWh each or about $3000 annually at typical energy rates. With a purchase price of about $2000 each the payback was below one year. Additionally, the Consumers Energy efficiency incentive program paid half the project cost. One observation was feeling the compressed air blowing out the exhaust port of the valve with the vane motor from a couple feet away, but with the piston motor the exhaust could hardly be felt by hand right at the exhaust port.

Hutchinson was able to get outsized savings due to downsizing the motor (1 hp to ½ hp) and going to direct drive instead of using a gear reducer. Of special note was taking the tachometer option for this motor. There is a process specification for the mix speed, but there was no way to know the mix speed with the original agitators. The tachometer allows the operator to set the mix speed as specified which is a process improvement.

While piston air motors cannot replace all vane air motors, their superior energy performance means they should be considered for some applications such as volatile paint mixing. Those applications would include an intrinsically safe requirement, low speed, high torque, and small size (< 2 hp). Since an electric motor eliminates compressed air completely it is still the preferred efficiency solution, but it is not always practical. Piston air motors can be an excellent choice in the right application. BP

For more information contact Jerry Zolkowski, PE CEM CMVP, Industrial Energy Management Principal Engineer, Consumers Energy at email: Gerard.Zolkowski@dnv.com or visit Consumers Energy at https://www.consumersenergy.com/

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Air Compressor Control Lessons Learned at Metal Products Company

By Ron Marshall, Marshall Compressed Air Consulting

It is very frustrating when you do everything right in purchasing and installing your compressed air system, but after some time things start to go terribly wrong. A metal products company producing parts for the transportation industry (name and location withheld to protect the innocent) has recently experienced this emotion. Their system was designed and built to achieve premium performance, yet in a recent compressed air assessment the numbers showed their system had surprisingly poor performance, and worse, their staff was unaware of the problems. This article discusses some of the challenges faced and some future solutions that could get their system back to higher performance levels.

Compressed Air System Set-Up

The company's compressed air system (Figure 1) consists of four (4) premium efficiency two-stage water-cooled lubricated screw air compressors (all 200 hp rated at 100 psi, one is VSD controlled) with total rated output rated at about 4,000 cfm capacity (1,050 cfm each). The air compressors are controlled using an automatic sequencer. All four compressors have variable displacement control through manually controlled spiral valves. The system is arranged with two compressors located on the East side of the plant and two on the West side.

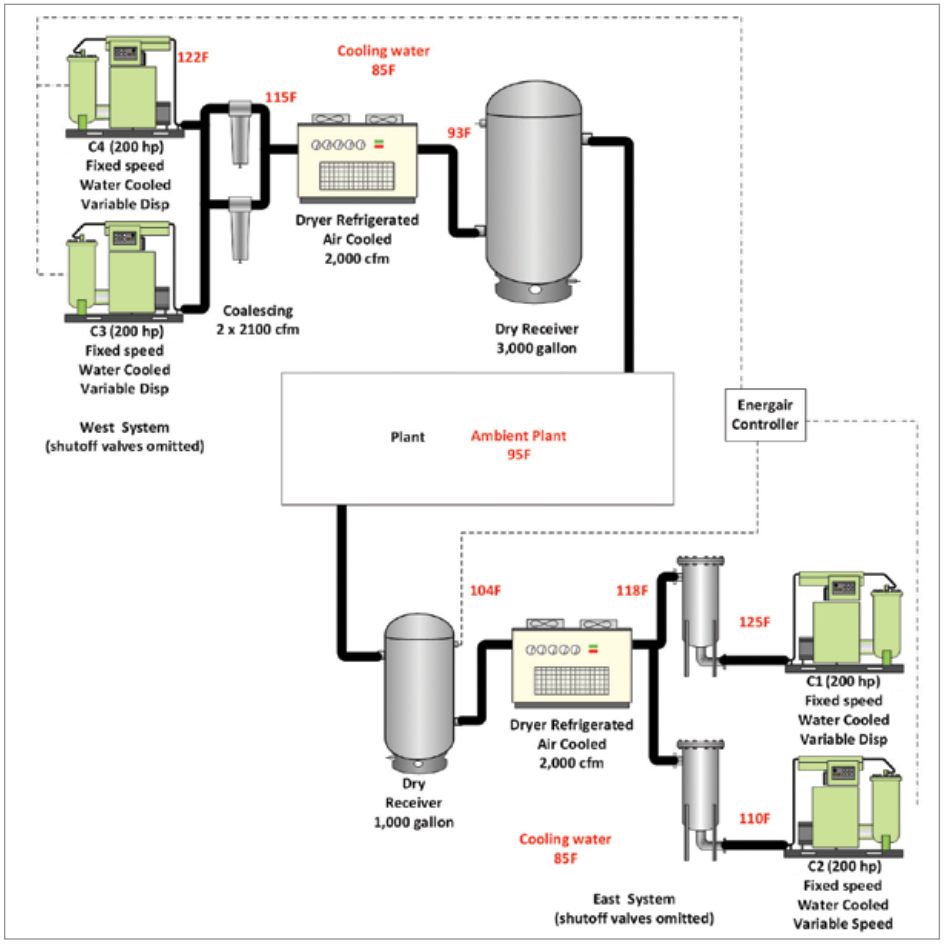

Figure 1. The compressors of this system are premium efficiency units that are controlled by a central sequencing controller. The customer chose to install equal sized base and VSD compressors which, due to extenuating circumstances, has created to a control gap issue.

The air is filtered and dried using two (2) air-cooled cycling thermal mass refrigerated dryers rated for 2,000 cfm. East-side air compressors have efficient mist-eliminator filtering applied to each compressor. West side has two oversized standard coalescing filters installed in parallel.

Baseline Study

Last year a utility funded baseline study was done using data loggers to measure and track compressor power, plant pressure, air dew point, and compressed air flow for a one-week period (Figure 2). The instruments showed surprising results; the system was running at much lower than desired efficiency, with specific power of 26.8 kW per 100 cfm, with the system consuming 2,900,000 kWh costing $197,000 per year. Optimal specific power for a system of this size and type, while running at about 95 psi, is around 17.5 kW/100 cfm. Leakage flow was estimated at 700 cfm during non-production hours representing 46 percent of the average air flow.

Air Compressor Control Lessons Learned at Metal Products Company

These results were surprising because the plant maintenance staff was regularly monitoring system specific power and leakage levels using a remote monitoring function of their compressor controller. The controller told them that their system was running quite efficiently at 17 kW per 100 cfm with a low level of leakage. Further investigation by a compressed air auditor revealed the reason for the differences in reported parameters.

Baseline Showed Problems

The initial look at the baseline readings showed some obvious problems (Figure 2). A well-controlled system using a sequencing controller with both fixed speed and variable speed compressors should be showing a pressure profile like that indicated at point 1, a flat profile with very little change in pressure, except when base compressors switch on or off. Problems observed:

1. Normal VSD controlled pressure profile is quite flat due to precise electronic control,

2. The sawtooth waveform shows compressors constantly loading and unloading which is the result of control gap due to a mismatch between the size of the VSD and the base air compressors,

3. C3 was running partly loaded either with inlet modulation or variable capacity, the compressor controller was expecting that all the running compressors would be fully loaded,

4. The VSD compressor was showing low amps, meaning it likely had an output much less that its rated capacity, this caused "control gap".

5. C4 was running unloaded as a result of production staff putting the unit in manual control while trying to keep the pressure constant,

6. Weekend loading showed significant non-productive flow, usually indicating high leakage levels, however, the installed flow meters had become contaminated (Figure 3) and were showing incorrect lower flow values, leading the maintenance staff to believe their leakage levels were acceptable.

Controller Reporting Errors

Due to local compressor control issues, contamination of the flow meters, and the characteristics of the compressor controller reporting algorithm, the maintenance staff were not receiving accurate information about how

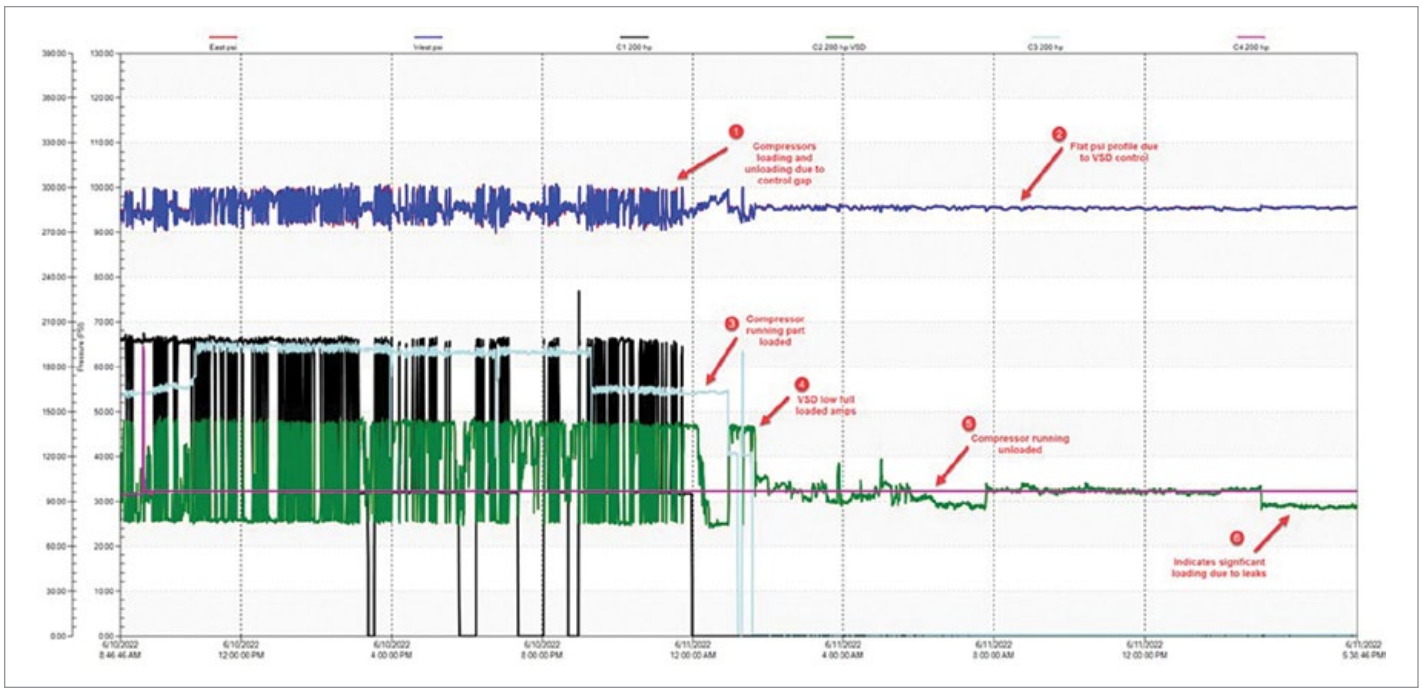

Figure 2. The initial baseline data logging showed some obvious problems with compressor control, this was not a problem caused by the compressor sequencer, but the result of some local compressor control issues, including unwanted human intervention. These issues caused the controller HMI to report incorrect results.

well their system was running. This is a common characteristic of compressor controllers, the reported power and flow values used in calculating system specific power and flow are often not real numbers, but are simulated based on pre-programmed compressor characteristics entered into the memory during the controller commissioning. The reason this is done is because most compressed air systems do not have power meters and flow meters installed, so to give compressor operators some indication of system operating parameters various assumptions are made:

- The controller assumes if it sends a load signal to the compressor it will be fully loaded producing full rated flow and consuming full rated power,
- In unloaded condition the controller assumes the programmed unloaded power and zero flow,
- In stopped condition zero power and flow are assumed.

With this system, due to problems with local compressor control, there was a mismatch between the reported flow and calculated actual flow. For example, compressor #3 control had a sticking inlet valve causing the compressor to output only 40% of its flow, yet the controller

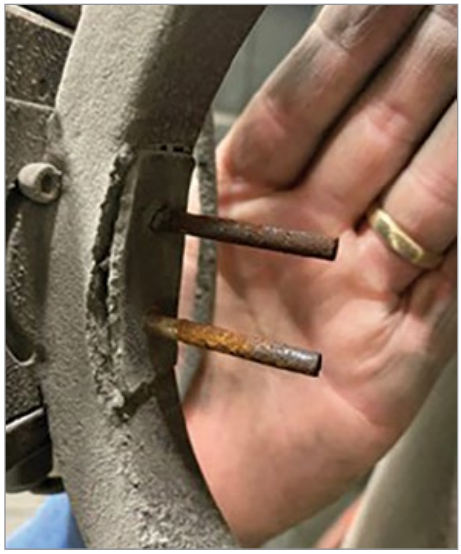

Figure 3. Due to dirty and hot environmental conditions the thermal mass flow meters installed at this site were contaminated and reading low, leading maintenance staff to believe their leakage levels were acceptable.

Air Compressor Control Lessons Learned at Metal Products Company

assumed 1,000 cfm output, and this is what it reported to the controller interface.

An additional problem was caused by personnel in the plant playing with the compressor controls. Occasionally plant personnel perceived that the compressed air pressure was too low for their liking, so before critical production activities took place, they would place the compressor controls in local mode with the auto shutdown feature turned off. This can be easily done because it was a simple push button function on the local compressor control. The personnel were unaware that doing this would make the main sequencer blind to the operation of the manual controlled compressor and would allow the compressor to run unloaded, wasting power for extended periods of time.

Environmental and Temperature Issues

Due to the characteristics of the operations within the plant there was a significant amount of dust contained in the ambient air. This made it necessary to purchase water-cooled compressors to avoid cooling issues, however, over the years the coolers on the compressors started to become contaminated. Figure 1 showed some challenges with the discharge temperatures of various air compressors which was overloading the air dryers.

The amount of water vapor doubles with every 20 degrees F increase in compressor discharge temperature. The air dryers are only rated for 100 degrees F inlet temperatures, causing the dryers to be overloaded during hot summer days. Further to this, some dust from the ambient air that gets by the compressor inlet filters and is ingested by the air compressors, then mixed with the water within the compressed air system, and then contaminates the dryer condensate drains, causing them to fail. This caused higher than desired dew points of around 80 degrees F, risking the presence of free water in the compressed air pipes.

The high ambient temperatures within the plant caused further problems with the VSD compressor. Staff found they would lose the main drive motor due to bearing failure if they allowed the compressor to go to full rpm, so in self-defense the maximum speed of the VSD drive was manually turned down. This saved the motor but caused a mismatch in capacity between the VSD and the fixed speed compressors.

Control Gap Sizing and Control Rules Broken

One basic rule in compressor control is that all the running fixed speed compressors should be fully loaded, and if they are not needed they should automatically turn off. And only one compressor, the VSD in this case, should be taking part load. The maintenance of this rule is the job of the compressor sequencer.

There is also a general rule in sizing VSD compressors that operate in a system with fixed speed compressors. If this rule is broken there will be control gaps occurring at various places along the system capacity profile. The rule states that the variable part of the VSD capacity must be equal to or larger than the largest fixed speed compressor with which the VSD must work.

Both of these rules were being broken in this plant and as a result the efficiency was poor. For this system the fixed speed compressors have a capacity of about 1,000 cfm fully loaded, however, the capacity of the VSD compressor, with its maximum rpm adjusted downward due to motor problems, was only 800 cfm. This created a control gap at flows between 800 and 1,000 cfm and another gap at a system flow of 1,800 to 2,000 cfm, and of course for this system Murphy's law intervenes, making sure significant hours are spent within the control gap. In looking at Figure 2 we can see the typical sawtooth waveform on the pressure profile, a sign of control gap when using a VSD compressor. In this control gap one or more fixed speed compressors will fight for control with the VSD, causing the system to run poorly, even though it has an efficient central controller installed.

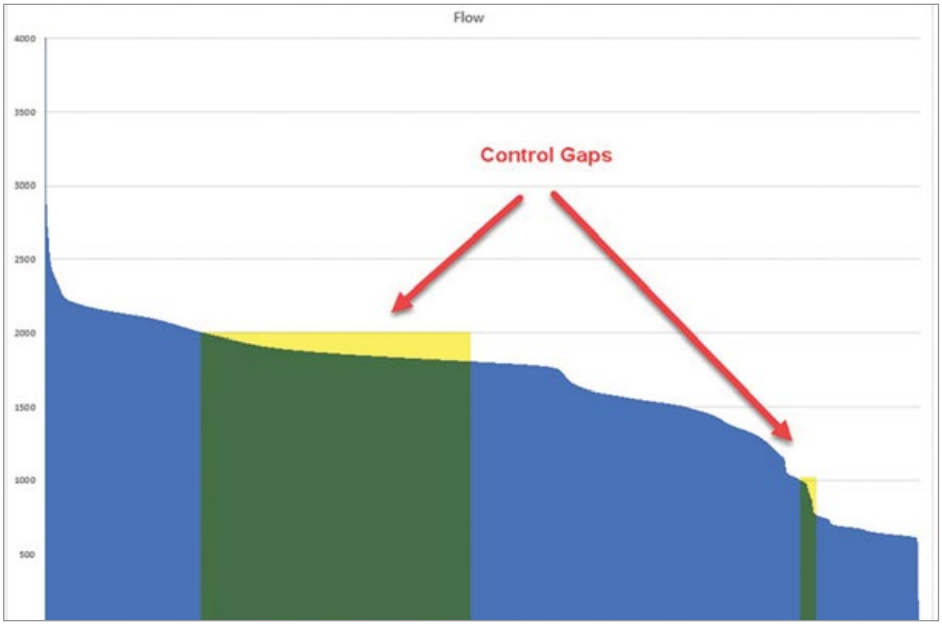

Figure 4. The flow profile histogram of this system shows that the system is within the two control gaps a significant percentage of the time.

Leakage Detection & Repair Efforts

Further study was done to try to detect and repair compressed air leakage with the goal of saving significant energy. An initial detection effort was carried out using a standard ultrasonic leak detector gun, however some challenges were encountered. Many leaks were in locations that were difficult and dangerous to access behind locked barriers, the site had many areas where molten metal or very hot items made feeling around to locate a leak a safety risk to personnel. This made the exact location of the leakage almost impossible to identify. In addition, there were many large leaks that were masking out the sound of smaller leaks. The initial leak audit found about 28 large leaks that needed attention.

During the audit a demonstration unit of a Fluke ii900 Industrial Acoustical Imager came available for use. An additional full plant scan using this device increased the number of total leaks found to 40, an increase of 40%. We also found that the time taken in identifying the exact location of the leaks in this complex plant was reduced by about 75% when the new detector was used.

Air Compressor Control Lessons Learned at Metal Products Company

Conclusion

Improvements at this plant are ongoing with the plan to:

- Reconfigure the compressor capacity to avoid control gap,
- Train plant staff to keep away from changing compressor control modes,
- Adjust and repair local control to maintain fully loaded fixed speed compressors,
- Improve compressor cooling, repair condensate drains,
- Repair and install flow and power meters connected to a separate monitoring system so real readings can be obtained to ensure the system is running correctly,
- Repair leakage and maintain an ongoing leakage repair program.

At the time of this writing some good improvement has already been achieved through some simple local air compressor control adjustments, reducing the average system specific power to about 20 kW per 100 cfm, saving about $50,000 per year, but in order to gain long term permanent savings some additional work will be required. Leakage has already been reduced to under 500 cfm. BP

For more information about this article contact Ron Marshall, Marshall Compressed Air Consulting, tel: 204-806-2085, or visit www.marshallcac.com

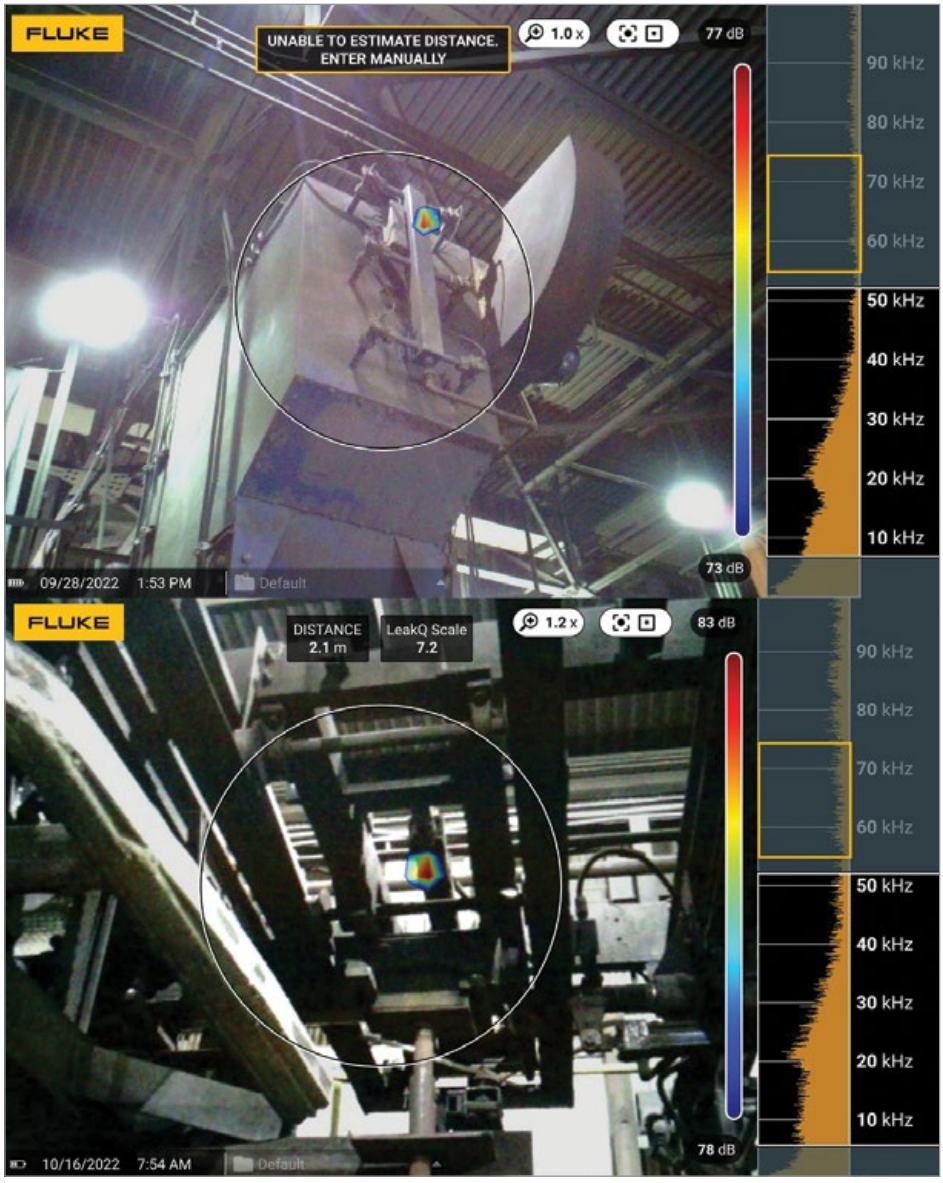

Figure 5 Top: The elevated leak on the dust collector manifold was missed by the ultrasonic gun but was found with the Fluke ii900 Industrial Acoustic Imager and easily identified from the ground.

Figure 5 Bottom: a large leak in a heat treatment furnace door mechanism was difficult and dangerous to reach when detected using an ultrasonic gun, but it is quite easy to identify, classify and estimate when shown on a Fluke ii900 Industrial Acoustic Imager (Source: Fluke ii900).

To read similar ***Air Compressor Control or Leak Detection*** articles, visit https://www.airbestpractices.com/system-assessments/compressor-controls

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Compressed Air Technology News

FS-Elliott Celebrates 60 Years of PAP Plus

Since 1962, FS-Elliott has been a world-class manufacturer intent on producing reliable air solutions for countries worldwide. Their compressors incorporate the latest aerodynamic and control system technologies to ensure performance with lasting durability. This fall, FS-Elliott celebrated their tradition of excellence, quality, and innovation with sales training and a 60-year commemoration of PAP Plus.

"Ever since FS-Elliott developed the PAP Plus 60 years ago, it has been exciting to watch this company grow into what it is today. Over time, we have built great relationships with our channel partners and customers, which is why FS-Elliott is a global leader. The week's celebrations have been a great opportunity to celebrate all the things that make FS-Elliott unique. With the development of the Welcome Center, we hope to continue influencing our team, customers, and channel partners for another 60 years," said Paul Brown, President of FS-Elliott.

For the week of excellence, FS-Elliott invited channel partners and channel partner managers for three days of training. Sales training topics included centrifugal performance optimization, benefits of sales tools, stock levels and lead times, products, product development, aftermarket updates, and supplier presentations. FS-Elliott Product, Engineering, and Aftermarket teams led the training.

To end the week, FS-Elliott had the grand opening of the Welcome Center. The development of the Welcome Center shares where they have been and where they are going by showing FS-Elliott's past, present, and future. Each period takes up part of the center for visitors to walk through. The past wall has a timeline of significant FS-Elliott events, the present wall displays engineered components, and the future wall highlights environmental and energy initiatives.

FS-Elliott's Welcome Center invites all channel partners and customers to come and visit.

About FS-Elliott

FS-Elliott is a global leader in the engineering and manufacturing of oil-free, centrifugal compressors, with operations in over 90 countries. For 60 years, FS-Elliott has combined commitment to quality with advanced technology so our customers can increase their productivity and lower system operating costs. For more information, visit www.fs-elliott.com.

FS-Elliott celebrates 60 years of PAP Plus with a week of celebration.

BOGE Expands S-4 Series for the 45 to 75 kW Performance Range

It's not only in foundries, the mining sector, and the construction industry where dust and dirt can hamper even the best efforts to generate reliable, continuous compressed air. Other areas – including the food industry – find themselves facing challenging conditions. And this is where a compressor with a virtually maintenance-free hermetically sealed direct drive comes into its own: wear and tear are minimized, which increases

BOGE's S-4 series of screw air compressors is now also available in the 45 to 75 kW performance range.

the device's service life. All of the models in BOGE's S-4 series have this "IntegrateDrive" airend – including the new compressors with a performance range of 45 to 75 kW.

Compressor manufacturer BOGE has once again expanded the fourth generation of its S series, meaning it now covers the entire 45 to 150 kW performance range. All models are characterized by quiet, reliable operation and have excellent efficiency values. The compressors generate high free air delivery at low specific power consumption. The energy use of the new 75 kW compressor has been reduced by over 12% compared with its predecessor, while the free air delivery has increased by almost 9%. Generously sized components reduce internal pressure losses, and with a footprint of just 1.20 m x 2.00 m, the housing of the new models is considerably smaller than its older siblings. These new compressors even now come with the particularly high-performance, low-energy IE4 motors and permanent magnet motors fitted as standard.

The innovative vertical oil separation concept ensures very low residual oil content, minimal pressure losses and a long service life. The internal cartridge is quick and easy to remove and replace. Maintenance takes place from two sides with just a few simple movements – the intake filter is accessible, and both the oil and air coolers can easily be removed and cleaned. These new models are also special thanks to their quiet running. "We've been able to reduce the noise in the 45 kW performance

Compressed Air Technology News

class by more than an extra 8 dB(A)," said Frank Hilbrink. "And thanks to this reduction, we've also ensured greater flexibility, as the compressor can now be used in more sensitive environments".

Thanks to the new models in the S-4 series, BOGE is now able to offer companies with reduced compressed air demands reliable, energy-efficient technology, even in situations where temperatures can exceed 40°C. For these critical installation conditions, BOGE has a high-temperature design which boasts improved cooling.

About BOGE Compressors

BOGE America is the USA based America's subsidiary of BOGE KOMPRESSOREN Otto Boge GmbH & Co. KG based in Bielefeld, Germany. Whether for centrifugal compressors, screw compressors, high-pressure piston compressors, scroll compressors, controls, air treatment equipment, complete systems or individual devices, BOGE meets the most diverse requirements and highest standards – in a precise and customer-oriented manner. BOGE solutions are used by all sectors of industry to supply compressed air for a wide range of manufacturing processes. The USA Operations of BOGE America stocks the various technologies of high-quality compressors and spares for immediate support to needs. Compressed air systems are designed, sold and serviced through a dedicated network of over 50 distributors in North, Central, and South America. The USA Operations is also the "Center of Excellence" for Technical Trainings for our partners to ensure Top Level Support for the consumer. For more information, visit www.boge.com.

Emerson Introduces ASCO Series 209 Flow Control Valves

Emerson introduced the ASCO™ Series 209 proportional flow control valves, which offer the highest standards of precision, pressure ratings, flow characteristics and energy efficiency available in a purpose-built, compact architecture. With this combination of size and performance, Series 209 valves allow users to precisely regulate the flow of fluid in a wide range of devices that require exacting performance, like those found in the medical equipment, food and beverage, and heating, ventilation and air conditioning (HVAC) industries.

Accuracy, response time and repeatability are critical in high-precision flow control applications, such as controlling tool speed in dental chairs, the flow of steam in coffee makers, water flow in cooling systems and hydrogen flow in fuel cells. Series 209 valves have low hysteresis (less than or equal to 5%), excellent repeatability (less than or equal to 1%) and high sensitivity (less than or equal to 0.2%) that contribute to their precision.

"Proportional valves are key components that can significantly impact equipment performance and efficiency," said Shivam Chauhan, commercial product marketing manager, Europe, the Middle East and Africa at Emerson's discrete automation business. "We designed the ASCO Series 209 valves to deliver the highest level of performance in a small footprint, giving our customers the flexibility and confidence to engineer products that drive innovation, foster sustainability, lower costs and improve people's lives."

The low power consumption and fast response time (less than or equal to 15 milliseconds) of Series 209 can extend battery life in devices powered by them and optimize system

ASCO Series 209 proportional valves offer superior precision, flow and power consumption for medical devices, hydrogen fuel pumps, food equipment and more.

performance and efficiency. An improved internal design prevents metal-on-metal contact that causes clicking, which allows valves to operate at extremely low sound levels that are crucial for occupant comfort and well-being in medical, commercial building and food service and hospitality environments.

Series 209 valves meet global approvals, including Underwriters' Laboratories (UL), United Kingdom Conformity Assessed (UKCA) and European Conformity (CE) and include a range of options that tailor valves for specific applications. For instance, Series 209 valves can be cleaned for critical applications like oxygen therapy devices and come in different coil configurations that add flexibility and simplify installation. And a selection of elastomers ensures compatibility with various media, including elastomers free of silicone that can withstand alcohol and sulfur in demanding applications like painting and powder coating as well as elastomers approved by the United States Food and Drug Association (FDA) for food and beverage applications.

Series 209 valves join Emerson's comprehensive offering of industry-leading proportional valve technology. For more about Emerson's ASCO Series 209 proportional flow control valves, please visit www.Emerson.com/Proportional.

About Emerson

Emerson, headquartered in St. Louis, Missouri (USA), is a global technology and engineering company providing innovative solutions for customers in industrial, commercial, and residential markets. Our Automation Solutions business helps process, hybrid, and discrete manufacturers maximize production, protect personnel and the environment while optimizing their energy and operating costs. Our Commercial and Residential Solutions business helps ensure human comfort and health, protect food quality and safety, advance energy efficiency, and create sustainable infrastructure. For more information visit www.Emerson.com.

Compressed Air Technology News

ELGi Rebrands Portable Air Compressor Line in North America

ELGi Compressors USA, Inc (ELGi), a subsidiary of ELGi Equipments Limited, one of the world's leading air compressor manufacturers, announced the strategic rebranding of its portable air compressor line in North America, previously branded as Rotair. ELGi acquired the Italian-based portable air compressor manufacturer, Rotair, in 2012. Rebranding "Rotair" to "ELGi" will strengthen the company's presence in the North American portable air compressor market by leveraging ELGi's established credibility. The rebranding of ELGi's portable compressors coincides with ELGi's 10th anniversary since expanding into the North American market. ELGi's recognition has grown significantly in the last decade due to its innovative air compressor technology and expanding network of distribution partners.

"The North American portable air compressor market is a key focus area for ELGi. The market fueled by the expansion of urban population growth, favorable government policies, industrialization, and manufacturing activities is estimated to grow at a healthy rate," said Anvar Varadaraj, President of ELGi Compressors USA, Inc. "Over the past ten years, ELGi has established reliable distribution and brand recognition in North America. Globally, the ELGi brand is synonymous with quality and reliability. We are proud to put the ELGi name and logo on our portable air compressors."

The Rotair brand of portable air compressors will now be branded as ELGi compressors in North America.

Beginning in December 2022, the "Rotair" branded portable compressors will only feature the ELGi logo and brand colors in North America. The robust manufacturing of the compressors and the responsive service that supports their notable UPTiME® on job sites will remain the same.

ELGi offers nine models in its portable air compressor lineup ranging from 75 CFM – 900 CFM. Portable air compressors support various construction, industrial, and infrastructure applications. ELGi's range of portable compressors is designed to be durable, fuel-efficient, quiet, and reliable. For convenience and mobility, units are available in trailer or skid mount versions. All ELGi portable air compressors are backed with a five-year/unlimited hour air-end warranty.

"We are excited to introduce the new look with the strong ELGi brand to the field," said Zeke Hendrix, Vice President, Portable Compressors. "Our existing portable compressor channel network will continue its commitment to the market with reliable machines and customer-focused support that sets us apart from the competition."

About ELGi North America

ELGi Compressors USA, Inc, headquartered in Charlotte, NC, is a subsidiary of ELGi Equipments Limited, a leader in compressed air solutions for over 62 years. Established in 2012, ELGi Compressors USA, Inc, in conjunction with its subsidiaries, Pattons, Inc, Pattons Medical LLC, and Michigan Air Solutions Inc, offers a comprehensive range of compressed air products and services. Our product offering includes oil-lubricated and oil-free rotary screw and reciprocating compressors, dryers, filters, and ancillary accessories. ELGi and its subsidiaries serve multiple industry verticals spanning medical applications, pharmaceuticals, food & beverage, construction, manufacturing, and infrastructure. For more information, visit www.elgi.com.

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"We've got to have the correct compressed air volume, psi and cleanliness at every CNC machine."

— Jeff Smith, Building Supervisor, Roush Yates Manufacturing Solutions (April 2022 Issue)

"This major automotive plant now has a compressed air system operating at optimal efficiency – this has helped them earn ISO 50001 Certification."

— Hector Lara, President, Airtec (March 2022 Issue)

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Compressed Air Technology News

Festo Introduces Ultra Compact ADN-S Pneumatic Cylinder

Festo adds a new space-optimized product to its line of pneumatic cylinders – the ultra-compact ADN-S – for performing small movements in tight quarters and, in so doing, helping machine designers keep their projects as space efficient as possible.

Festo took the ISO standard ADN double-acting cylinder and shrank the housing length to create a significantly smaller, lighter weight, and attractively priced choice for space-critical applications.

Festo ADN-S to its line of pneumatic cylinders for performing small movements in tight quarters.

The ADN-S is also smaller than other compact double-acting cylinders, making it ideal for such tasks as testing cellphone keys. For lithium-ion battery manufacturing, there is an ADN-S variant that only contains trace amounts of copper, zinc, and nickel, a requirement for components in battery applications.

ADN-S comes with multiple mounting options and a choice of fixed or no end-position cushioning. A proximity sensor can be added. The piston rod is available with internal or external threading, in diameters 6-60 mm and in standard strokes 5-50 mm.

The ADN-S joins the Festo DSNU-S round cylinder, a space-optimized version of the ISO DSNU round air actuated cylinder, in meeting the demand for small drive components that can perform with the same reliability, consistency, and durability of the larger cylinders from which they are derived. ADN-S, like DSNU-S, ADN, and DSNU cylinders, are part of Festo's Core Range of widely applied products that are always in stock and ready for shipping throughout North America.

About Festo

Festo is a leading manufacturer of pneumatic and electromechanical systems, components, and controls for process and industrial automation. Celebrating 50 years in the U.S., Festo Corporation has continuously elevated the state of manufacturing with innovations and optimized motion control solutions that deliver higher performing, more profitable automated manufacturing and processing equipment. Through advanced technical and industrial education, Festo Didactic Learning Systems and its partners prepare workers for current and future manufacturing technologies. For more information on the advantages of working within the Festo ecosystem – the ecosystem that leads to less engineering overhead, fast time to market, and seamless connectivity – visit https://www.festo.us.

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