The Magazine for ENERGY EFFICIENCY in Compressed Air, Pneumatics, Blower and Vacuum Systems

COMPRESSED AIR BEST PRACTICES

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December 2012

Air Compressor & Blower Controls

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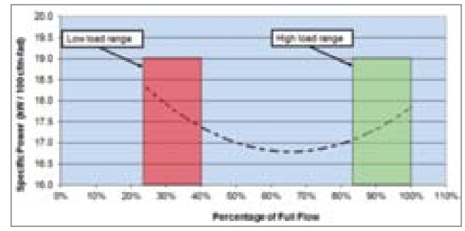

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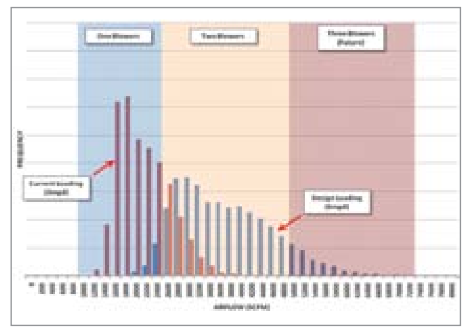

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COLUMNS

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FROM THE EDITOR | Control the Waste

How much energy is needed for maximum productivity and how can it be provided in the most efficient manner possible? That question applies to almost everything in life when you think about it.

The 35th World Energy Engineering Conference was held, in early November, in Atlanta. I was again motivated by the experiences shared by industrial Energy Managers from firms like Archer Daniels Midland and Toyota who are dedicating their careers to reducing kW, natural gas, water and waste at their factories. We were pleased to again chair a session on "Best Practices in Compressed Air" and thank our speakers for sharing their knowledge. You can find a summary in our Industry News column.

"Applying Variable Speed Compressors in Multiple Applications" is the article penned by Neil A. Mehltretter, from Kaeser Compressors. It's an excellent real-world recount on the technology and how to best apply it. Many factories have multiple air compressors. Nicolas De Deken, from EnergAir, provides us with a nice case study on how a blow molder was able to use a master controller to control multiple 40 bar air compressors at a blow molding facility.

Measuring flow in compressed air systems is, in my opinion, the next step for compressed air systems. Point-of-use flow meters can tell users if compressed air is being used unnecessarily while supply-side flow meters can verify compressor performance and allow for "billing" to different compressed air customers. Hank van Ormer provides us an excellent article on how to read the "interval data" that provides users with feedback from flow meters. Ron Marshall, on behalf of the Compressed Air Challenge®, also contributes the article, "Stop Operating Blind-Use a Flow Meter".

Blower technology and how to control it, in the wastewater treatment industry, is the focus of an excellent article from BioChem Technology titled, "Improved Aeration Efficiency Through Design and Control." This is one of those articles that require multiple reads to absorb.

We thank the authors above for sharing their knowledge and thank you for your support and for investing in ***Compressed Air Best Practices*®.** BP

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COMPRESSED AIR, PNEUMATICS, VACUUM & BLOWER INDUSTRY NEWS

Gardner Denver Confirms Exploration of Strategic Alternatives

Gardner Denver, Inc. confirmed that its Board of Directors is exploring strategic alternatives to enhance shareholder value. These alternatives could include, among other things, enhancing the Company's existing strategic plan or a possible sale or merger of the Company.

The Company stated that no decision has been made and that there can be no assurance that the Board's exploration of strategic alternatives will result in any transaction being entered into or consummated.

TPG Capital, Onex Corp., KKR & Co., the Blackstone Group and Bain Capital are among the private-equity firms considering offers, Reuters reported. They went on to say that sources said TPG and Onex may bid together on a sale that may exceed $3 billion.

Gardner Denver shares jumped 21 percent when the news broke on October 26 to $66.00. They finished the week at $69.96 against a declining market worried about the "fiscal cliff". www.gardnerdenver.com

The 35th World Energy Engineering Conference a Success

The Association of Energy Engineers (AEE) announced a highly successful World Energy Engineering Conference (WEEC), held October 31-November 2 in Atlanta. Attendees came from the AEE's strong membership base of over 16,000 professionals in 89 countries. Founded in 1977, the AEE is widely recognized for it's energy certification programs — most notably it's C.E.M. (Certified Energy Manager) Certification.

Albert Thumann, P.E., C.E.M., Executive Director, Association of Energy Engineers.

Compressed Air Best Practices® Magazine has been fortunate to be associated with the Association of Energy Engineers since we launched the publication. Most of our Editorial Board Members are Energy Managers who are AEE Members. Representing companies like PepsiCo, Archer Daniels Midland, Visteon, Saint Gobain, Briggs & Stratton, CalPortland, we meet once a year at the World Energy Engineering Conference and hold our Annual Editorial Board Dinner.

Every year over the past four years, the WEEC has allowed our Editor, Rod Smith, to chair a session titled, "Best Practices in Compressed Air". Part of the Industrial Energy Management track, we invited four speakers this year; Frank Moskowitz from Atlas Copco Compressors, Pierre Noack from Aerzen, Nitin Shanbhag from Hitachi America, and Neil Mehltretter from Kaeser Compressors.

Attendance was excellent. We estimated at least fifty people attended the session. In order of appearance, we'd like to provide our readers a brief description of the excellent presentations.

Frank Moskowitz is a Compressed Air Systems Analyst with Atlas Copco Compressors. His presentation was titled, "The 14 R's of Compressed Air". Frank outlined ways to reduce leakage losses, reduce pressure at points of use, reduce pressure at the source, reduce system pressure fluctuations, reduce the number of compressors at reduced capacity, remove inappropriate applications, reduce system pressure drop losses, remove the presence of moisture, remove condensate without air-loss, reduce production downtime through preventive maintenance, record system data and maintenance, review air usage patterns regularly, recover heat, and reduce energy costs.

Pierre Noack is the President of Aerzen USA. His presentation was titled, "Energy Savings in Low-Pressure Air: Pneumatic Conveying, Wastewater Treatment, and Gas Compression". Pierre identified pressure drop due to piping design and incorrect blower technology as areas to focus on to improve pneumatic conveying systems. In wastewater plants,

Chris Davis, Steve Clasen, Jimmy Ford, Frank Moskowitz from Atlas Copco and Walter Smith from ETSI Consulting (left to right).

Neil Mehltretter, System Design Manager for Kaeser Compressors.

DO control, air flow management, and blower selections was reviewed. In gas compression, areas such as landfill gas, biogas, gas flared from industrial plants, and waste heat were the areas where we need to achieve a balance between safety, reliability and costs.

Nitin Shanbhag is the Senior Manager, Charlotte Business Operations, for Hitachi America's Air Technology Group. His presentation was titled, "The Need for Oil-Free Compressed Air". Nitin began with an explanation of where oil comes from in a compressed air system whether from ambient air or from compressor lubrication. He then gave a description of how an oil-free air compressor works and listed common oil-free applications. ISO 8573.1 Air Quality Classes were introduced as a good way to develop an air quality specification in a manufacturing organization. Finally a list of oil-free compressed air users was provided

Pierre Noack, President of Aerzen USA.

COMPRESSED AIR, PNEUMATICS, VACUUM & BLOWER INDUSTRY NEWS

Compressed Air Best Practices® Magazine had the opportunity to interview the Founder and Executive Director, Mr. Albert Thumann, P.E., C.E.M., during the Conference.

CABP: Good morning. How do AEE membership trends look?

Thumann: Good morning. Reflecting growing market demand for energy professionals, membership in the AEE has doubled, over the past five years to 16,000 members. We've been at this since 1977 and it's exciting to see the arrival of the demand for the principles and skills we've been preaching for a long time.

CABP: What are your members from industrial companies telling you about their energy priorities?

Thumann: We have trained and certified energy managers from the largest U.S. manufacturing and process industries. 3M Corporation, for example, was our first Corporate Member and at last years WEEC in Chicago, held their annual meeting with all managers associated with their energy conservation and sustainability strategies.

Industrial Energy Managers are telling us more than ever that energy conservation not only greatly assists their corporate efforts to reduce their carbon footprint-but that energy management is a profitable endeavor that can be conducted without the help of energy incentives dollars coming from utilities.

CABP: How common are Sustainability Policies with your members?

Thumann: The "AEE Survey of the Energy Industry 2012: Market Trends Survey" provided us with many insights into our members' activities. Most AEE Members work for companies significantly engaged with sustainability. Fifty-nine percent (59%) of respondents said they have an established policy concerning sustainability and/or sustainable development with a further nineteen percent (19%) stating that a policy was in development.

Further, eighty-one percent (81%) of survey respondents stated that they have a set of established goals associated with their sustainability policy.

Survey respondents identified the components included in their sustainability policies. The top three areas identified were energy efficiency (87%), employee education (67%), and waste reduction and management planning (64%).

CABP: What impact does the cost of electricity have on your members?

Thumann: The "AEE Survey of the Energy Industry 2012: Market Trends Survey" provided us with insights into this area as well. Sixty-six percent (66%) surveyed said their electric rate had increased, twenty-one (21%) saw no change, and thirteen percent (13%) experienced a rate decrease over the past year.

Of those who experienced a change in their electric rate versus the prior year, nine percent (9%) of respondents experienced an increase greater than 15%, another nine percent (9%) saw an increase between 11-15%, 31% experienced an increase of 31%, and 38% saw a 1-5% increase.

CABP: What kind of work does the AEE do outside the U.S.?

Thumann: The AEE has 3,000 members outside the U.S. and a network of membership chapters is being added to our total of 87 chapters. We have regional directors, managing this growth, and our focus is on our core Certified Energy Manager training sessions. We just finished, for example, a C.E.M. course in Madrid.

When you look at Germany and Japan, for example, you have two countries who have just committed to a non-nuclear future. This means that for them, the topics of energy conservation, alternative energy, and CHP (combined heat and power) projects enabling decentralized power generation are more important than ever.

This is a good example of why the demand for professional energy management training and products has never been greater than it is today. This year, we are seeing a record turnout of equipment vendors here at our Expo. Conference attendees come, here from all over the world, for training and project ideas. It's an exciting time to be a energy professional!

CABP: Thank you for your time. Readers can visit www.aeecenter.org for more information.

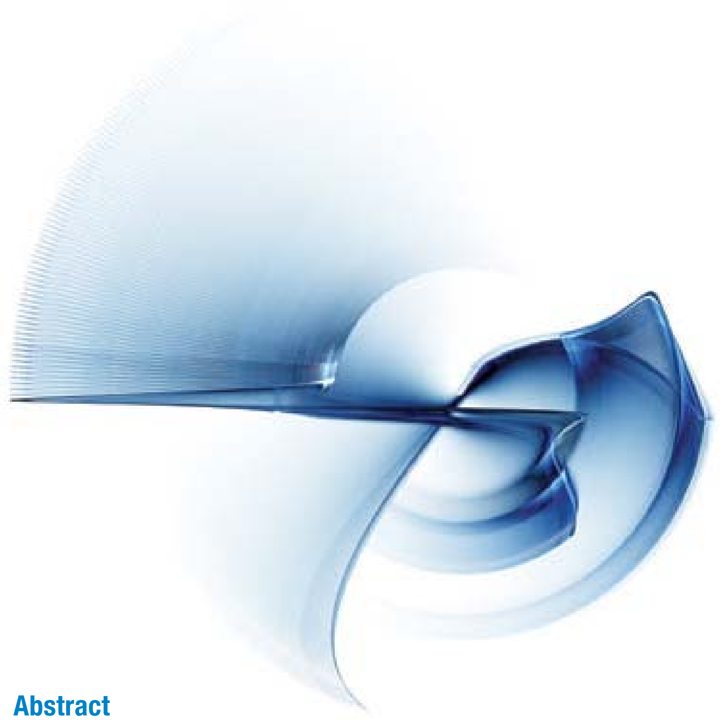
Nitin Shanbhag, Senior Manager Charlotte Business Operations, for Hitachi America's Air Technology Group.

along with examples of industries that are recently adopting oil-free air as their air quality standard.

Last and certainly not least, Neil Mehltretter is the System Design Manager for Kaeser Compressors. His presentation was titled, "Applying Variable Speed Compressors in Multiple Compressor Applications". The article supporting his presentation is published in this issue of Compressed Air Best Practices® Magazine. Using a lot of interesting interval data, Neil reviewed the proper application of variable speed compressors, differences between variable speed and fixed speed compressors, master controls and the demand profile, control gaps, and example systems with variable speed compressors.

We strongly encourage the compressed air industry to be involved with the Association of Energy Engineers. They are, in our opinion, the leading educational and training organization in the U.S. on energy efficiency. This is why Compressed Air Best Practices® Magazine is such a good fit and we feel fortunate to continue our association with the AEE in 2013. The AEE offers many ways to receive training and to promote technology through their three yearly conferences/expos, their membership chapters, and their Certified Energy Manager training courses. Visit www.aeecenter.org for more information.

To read more ***Industry News*** articles, visit www.airbestpractices.com



APPLYING VARIABLE SPEED COMPRESSORS IN MULTIPLE APPLICATIONS

APPLICATION SUCCESS STORIES AND IMPROVEMENT STORIES

By Neil A. Mehltretter, System Design Manager, Kaeser Compressors, Inc.

Abstract

Variable speed control for all types of industrial equipment is now readily available on the market with competitive pricing to non-variable speed controlled alternatives, including in the air compressor industry. With the advent of prescriptive rebate programs for variable speed compressors and other equipment, the demand for these types of controls has increased. General wisdom would recommend a variable speed compressor for all applications, or multiple variable speed compressors within each system. There are significant benefits for systems where the demand changes rapidly to be served by variable speed compressors; by varying the frequency of the input electricity to the motor, a variable speed compressor can speed up and slow down to match supply output to the customer's demand while maintaining a stable operating pressure within the system. However, many factors should be considered when selecting new air compressors — especially for multiple compressor systems. This paper will provide guidance on the design of variable speed compressors, how they can operate most efficiently with existing compressors, explain the tools necessary to consider when applying variable speed compressors to multiple compressor stations (or any compressors within a system), and provide examples of systems which required improvement as well as systems which were well optimized.

How Variable Speed Compressors Fit Within the Overall System

Variable Speed Compressors

Variable speed control for air compressors is not the panacea for compressed air system efficiency. It can be an important component of an optimized system, provided that it is properly applied. Many factors must be considered before choosing to add even a properly sized variable speed compressor to a system. To understand the part a variable speed compressor would play in creating an efficient system, it is important to take all of the system factors into consideration.

With regard to the variable speed compressor itself, factors to consider include the losses associated with the drive, the increased losses in the motor caused by harmonics in the power supply and the efficient operating range of speeds of the compressor. Drive losses can reduce efficiency 3-5% when compared to a fixed speed compressor. A variable speed drive improves the total energy efficiency only if such additional losses are exceeded by the benefits resulting from the capability to regulate the speed at less than full load conditions. An application where the compressor runs at any steady speed for prolonged periods of time could be made more efficient by using a properly-sized and controlled fixed speed compressor (or compressors) that does not have the losses mentioned above.

> "In poorly designed systems, it is not at all unusual for compressors to switch from load to idle every 20 seconds. This can result in an average power consumption of 90%+ to supply a demand of ~50%."
>
> — Neil A. Mehltretter, System Design Manager, Kaeser Compressors, Inc.

Fixed Speed Compressors

Fixed speed compressors are typically switched between load (the compressor is running and producing full flow), idle (the compressor is running but is not producing air) and stand-by (the compressor is off but ready to restart). Idle operation is necessary when the required switching frequency between full flow and zero flow exceeds the maximum permissible starting frequency of the motor.

Power consumption during idle is typically 15-35% of full load power consumption. However, for lubricated screw compressors, this low power level is reached only after the pressure in the separator has been relieved. This can take 30-60 seconds. In poorly designed systems, it is not at all unusual for compressors to switch from load to idle every 20 seconds. This can result in an average power consumption of 90%+ to supply a demand of ~50%.

Overall System Design

Designing a proper and efficient compressed air system requires knowledge of the strengths and weaknesses of each compressor type and how they should be applied. Because compressed air is an essential part of the manufacturing process and therefore an indispensable part of the infrastructure like electricity, interruption of compressed air supply can cause an interruption of production and also possible consequential damage. Reliability and availability of compressed air supply should be ensured by a certain redundancy to compensate for planned maintenance or breakdown. Generally this means that the number of compressors, the individual compressor sizes and the total combined flow of all compressors have to be chosen in such a way that an uninterrupted compressed air supply is ensured, even if the largest compressor is shut down for maintenance or if it fails. This philosophy can be extended to dryers and filters to ensure complete system redundancy.

For example, in a compressed air station with only two compressors, the smaller one would have to be sized to provide enough flow to meet the peak demand or that in a compressed air station with three compressors, the two smallest would have to be sized to provide enough flow for the peak demand. This example shows that realizing redundancy

APPLYING VARIABLE SPEED COMPRESSORS IN MULTIPLE COMPRESSOR APPLICATIONS

Application Success Stories and Improvement Stories

in compressed air stations with only two or three compressors is associated with large additional investment, as this typically increases the overall horsepower of the station. These circumstances in addition to possible improvements regarding controllability typically lead to the installation of several compressors in industrial compressed air stations.

In addition to the multiple compressor considerations weighing the costs and the benefits from including one or more variable frequency drive compressors should be analyzed. The costs would include capital as well as potential increased maintenance cost over the lifetime of the equipment, plus the increased complexity of the compressor requires advanced training in maintenance and operation.

It is well known that in multiple compressor installations the energy efficiency is significantly improved by the use of a master control which coordinates the operation of the individual compressors. The most important aspect of "coordination" in this context is to control the operational modes and the transition between these modes appropriately (e.g. load, idle, stand-by for fixed speed compressors, operating speed of variable speed compressors, shut down or start-up for all types of compressors).

The master control decouples the individual compressors from the system demand pattern by "translating" the actual values and the trend of the total demand along with the storage pressure, the actual and previous operating conditions, and the availability of the compressors, to an efficient control scheme for all compressors minimizing the total energy consumption.

In particular the control scheme applied should benefit from the individual advantages and avoid the individual disadvantages of the compressors in the system. These include:

- Supply short-term demand fluctuations using the control capability of variable speed compressors, but avoid long-term operation in less efficient operating points and frequent shut down or start-up
- Use the high full load efficiency of fixed speed compressors, but avoid long-term idle operation and frequent switching between operational modes

Installations with several fixed speed compressors combined with one or two variable speed compressors are very energy efficient over a large range of flows, if a master control is applied. The master controller will allow the variable speed compressor(s) to supply the short and medium-term fluctuation of the total demand to eliminate the need for frequently switching fixed speed compressors. The master controller will also operate the fixed speed compressors in such a way that the actual base-load demand is supplied by an adequate and efficient combination of compressors in load and in stand-by. In such installations with two variable speed compressors and one or more fixed speed compressors, the additional losses of the variable speed compressors should be exceeded by the efficiency gain of the entire system as the system rarely sees frequent switching and/or idling of fixed speed compressors. An overall cost analysis can be completed to determine the return on investment by adding a variable speed compressor(s) to the system as opposed to other alternative solutions.

System Sizing and Compressor Selection

Measuring the System Demand

Given the assumption that a variable speed compressor will be one of several compressors required to meet the total demand, the first thing required for properly applying a variable speed compressor, or any fixed speed compressor for that matter, is a demand profile. A demand profile is best if measured using a flow meter installed downstream of air treatment equipment and downstream of dry storage. This way the profile reflects the actual system demand and is not a supply profile. Measuring compressor response to system demand, a supply profile, will produce an approximation of the demand, but storage becomes a demand in that case and must be considered. Without a profile, it is very difficult to properly size the variable speed compressor that can cover

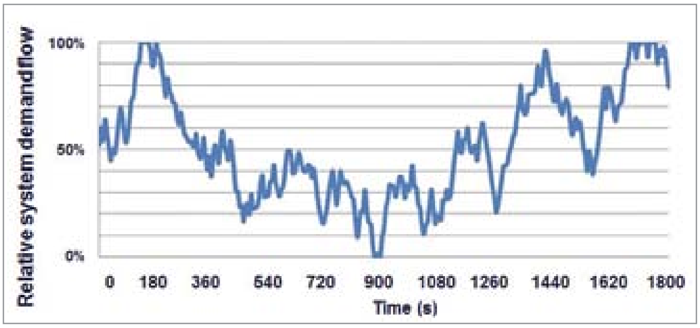


Figure 1: Sample demand flow profile.

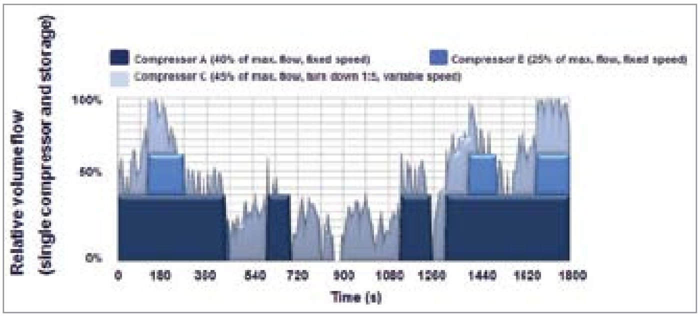


Figure 2: Multiple compressor system operated by a master controller.

the variations in demand in an efficient manner. This demand profile should accompany individual compressor operational signals, along with power consumption, and multiple system pressures. These signals together will provide an overall baseline of whether the supply is able to meet the demand.

Understanding the System Operation

An example of a possible, and simplified, flow profile is shown in Figure 1. The overall flow percentage is graphed against time in seconds.

Figure 2 shows how a master controller should operate individual compressors (in this example two fixed speed compressors and one variable speed compressor) to match the system demand illustrated in Figure 1 with minimum pressure fluctuations.

The compressors have been sized for the application so that the base-loaded, fixed speed compressors have a capacity that fits within the control range of the variable speed compressor. This allows the fixed speed compressors to be started and stopped when significant changes in demand occur while the variable speed compressor adjusts

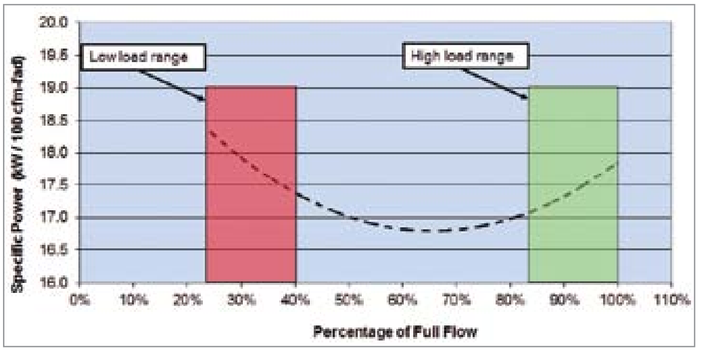


Figure 3: Sample efficiency of variable speed compressor.

for variations in demand that are within its control range. Frequent switching between load and idle on the fixed speed compressors is eliminated. The fixed speed machines are either at full load or stand-by (offline entirely).

Compressor Selection

In the example above, the compressor sizing includes two smaller fixed speed compressors and one larger variable speed compressor. When

APPLYING VARIABLE SPEED COMPRESSORS IN MULTIPLE COMPRESSOR APPLICATIONS

Application Success Stories and Improvement Stories

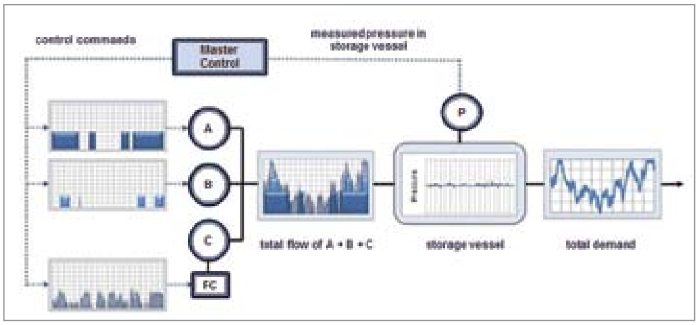


Figure 4: Characteristics of a compressed air system master controller.

base-load compressors are sized within the control range of the variable speed compressor, this ensures the ability of the station to maintain a stable plant pressure and maintain the highest efficiency possible throughout the prevailing demand profile.

The control range of the variable speed compressor is defined as the difference between maximum output flow of the compressor at rated pressure and the minimum flow of the compressor at rated pressure. When the base-load compressors are sized within this range, and the compressed air station includes a master controller, then the compressed air station can maintain a stable operating pressure at various flow levels. In the example, there are two different horsepower base-load compressors. This can allow the variable frequency drive compressor to operate within its maximum efficiency range at varying flow levels. Figure 3 highlights the general efficiency of a 350 hp variable speed compressor by graphing the percentage of full load flow against the compressor's specific power (kW / 100 cfm-fad). Note that the most efficient points are typically between 40% and 85% of full load which is supported by the data in Figure 3. These efficiency gains using a single variable speed drive compressor can be expanded to a multiple compressor station as a whole through advanced compressor controls.

Advanced Compressor Controls: The Master Controller

The key to effectively addressing changes in demand within a multiple compressor system is the correct type of master controller. The master controller should not simply generate multiple pressure bands and control each compressor within its assigned band. The controller must be able to maintain the most effective pressure band and control all compressors within that band. It must monitor the rate of change of the pressure to determine the change in flow demand and calculate the appropriate and most efficient response to that change. It must be able to monitor the starting frequency of all compressors in the system so that they can be quickly or immediately switched to stand-by and avoid any idle mode running. However, even with a sophisticated master controller, if the compressor selection is not appropriately made from the beginning, then the efficiency potential of the system can suffer.

Figure 4 illustrates how the master controller translates changes in system pressure into a suitable control scheme for the compressors using the same example in Figure 1 and 2. Note that none of the compressors are following the system demand. The controller separates their controls from the demand and determines how they should run to maintain a stable pressure and above the minimum required pressure.

By using the correct combination of master control and properly sized compressors, concerns about part-load efficiency of the fixed speed compressors is eliminated. They will not run any significant time in idle mode, running instead in full load or stand-by. It should also be noted that a back-up compressor in the system example would need to have a flow rate as great as, or greater, than the largest machine in the system. In an actual application, this flow profile would likely have resulted in more than just three compressors being specified. Breaking the demand into smaller units could reduce the size of individual compressors and allow for smaller back-up or back-up covered by multiple machines.

Selection by Analysis Revisited

It is critical to revisit the compressor selection. By designing the compressed air station based on measured data, the system is in a better position to be optimized at demands within the production than without measured data. In many cases, compressors are added as production equipment is added to the facility. In these cases, common wisdom suggests that simply adding a variable speed compressor on top of existing fixed speed compressors can provide significant energy savings. However, this typically does not address key areas of operation as it does not include a full understanding of the overall system dynamics. In these cases it is always recommended to

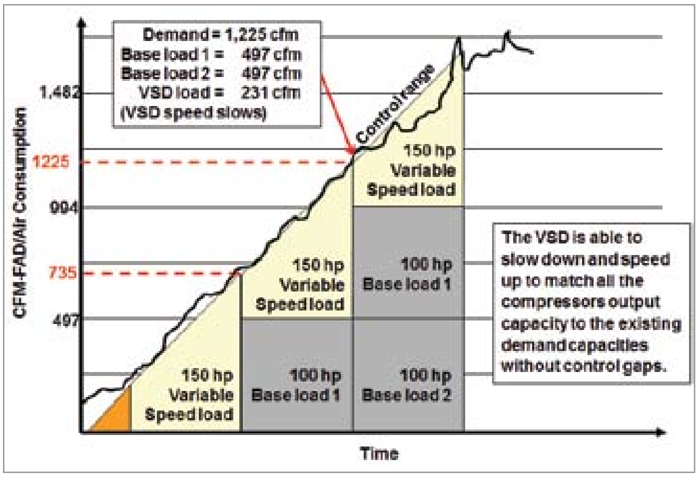


Figure 5: System selection to avoid control gap.

complete a comprehensive air demand analysis, or air assessment, to understand the compressed air dynamics.

What Is Control Gap?

Control Gap Explained

Often times the variable speed compressor selected is the same size as a base-load compressor or smaller. When designing a compressed air system, if the control range of the variable speed compressor is not considered, this can result in one or more compressors operating in an inefficient manner, such as cycling between load and idle of a fixed speed compressor or significant ramping up and down of the variable frequency drive — or both at the same time. When these types of events occur, the plant often refers to the compressed air system as "out of control," and an unusual pressure fluctuation in the facility persists which can affect production. This is commonly referred to as a "control gap."

The control range of the variable speed compressor is critical to avoiding a control gap. When one or more fixed speed compressor is sized within the variable speed compressor's control range, the control gap can be

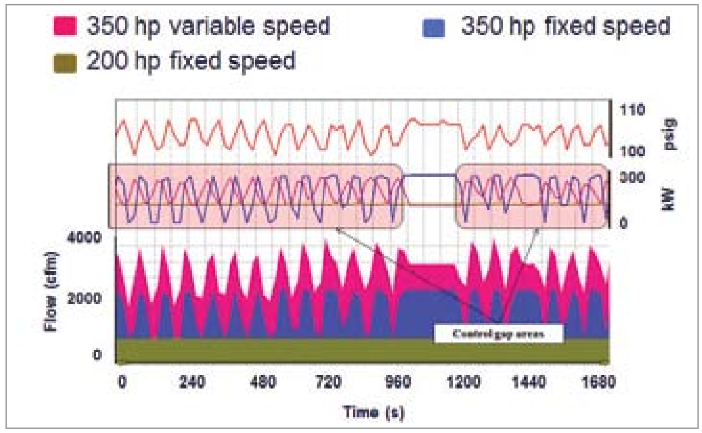


Figure 6: Control gap example 1 highlight.

avoided. Figure 5 shows an example system with 150 hp variable speed drive compressor and multiple 100 hp fixed speed compressors. The maximum flow of the 150 hp variable speed compressor is 735 cfm-fad at 110 psig and the minimum speed is 150 cfm-fad, therefore the control range of the variable speed compressor is 585 cfm-fad at 110 psig.

Continued on page 34.

Improved Aeration Efficiency through Design and Control

By Matthew Gray, Senior Process Engineer and Steve Kestel, Lead Systems Engineer, BioChem Technology, Inc.

With the recent and future increases of the cost of energy, operating a wastewater treatment plant (WWTP) as efficiently as possible has become one of the most important factors that operators and managers are facing today. The implementation of a properly designed aeration control system has been reported by the United Sates Environmental Protection Agency to reduce aeration energy by 25 to 40 percent.

An aeration system can be broken into three separate parts: airflow generation, airflow distribution, and aeration control. Airflow generation consists of aeration blowers. Airflow distribution consists of air piping, air control valves, and diffusers. Aeration control consists of blower control, air flow calculations, airflow meters, and dissolved oxygen meters. A good aeration system will need all three parts to work well together. If one aspect of design is lacking, the other two aspects will be affected and will likely cause the DO set point to be missed, with a potential of a permit to be violated and energy to be wasted. The goal of this article is to describe the process of designing an aeration system and present a case study of an advanced aeration control system.

The following sequence of calculations and design decisions can be used to provide a cost effective and energy efficient aeration system.

Process Oxygen Requirements

The first step of designing an aeration system is calculation of oxygen transfer requirements (OTR). The amount of oxygen required is dynamic, and will vary by time and location within the aeration basin. Oxygen demand is dynamic because the influent loading is diurnal, as shown in Figure 1 which depicts the diurnal pattern of influent ammonia concentration.

The calculation of OTR can be done by hand or spreadsheet for steady-state assumptions, but commercial activated-sludge-model simulation software packages such as GPS-X by Hydromantis, Hamilton, Ontario or Biowin by Envirosim, Hamilton, Ontario that can calculate the OTR dynamical, will provide values closer to reality. As with all activated sludge simulations, the better the influent data the better the results. Influent diurnal loading data of BOD, TKN and TSS is recommended, if possible. The results from the simulation will provide the complete range of OTR needed to calculate airflow requirements both dynamically and spatially.

Air Flow Calculation

Calculation of airflow is the next step after calculation of the process oxygen requirement. The amount of airflow required to achieve oxygen transfer requirement is dependent upon the diffuser selection and layout. Therefore, the calculation of airflow can only be completed after diffuser design is complete.

There are two basic types of diffusers available on the market, fine-pore and coarse bubble. Fine-pore has become the design standard for

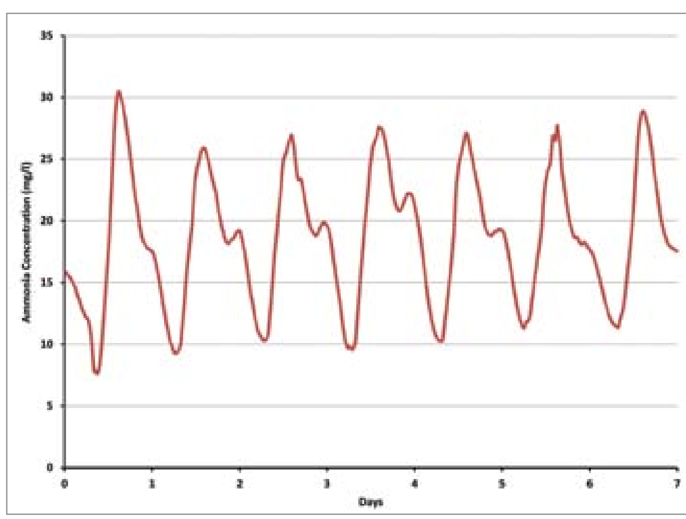


Figure 1: Seven days of influent ammonium readings.

activated sludge process because of the higher standard oxygen transfer efficiency (SOTE) compared to coarse bubble. SOTE is the percentage of the airflow's oxygen that is transferred into clean water at standard conditions. Fine-pore diffusers provide higher oxygen transfer because a larger volume of smaller diameter bubbles are created by the diffuser, thereby increasing the surface area of gas transfer.

The SOTE is not only influenced by the diffuser type, but also the depth of the diffusers and the airflow per diffuser ratio. All SOTE values are based on testing performed at the diffuser manufacturer's facility with clean water at standard conditions. A conversion from SOTE into field oxygen transfer efficiency (OTE) that takes into account the influence of the activated sludge on gas transfer is necessary. The Fine Pore Aeration Systems Design Manual by the USEPA provides the methods to calculate the ratio of (OTE/SOTE) that is seen in the field and is used to calculate the airflow needed to meet the OTR.

The design of the activated sludge process affects the overall efficiency, so layout of the diffusers needs to take account of the OTR to ensure the design conditions are meet in a energy efficient way.

Hydraulic Design: The aeration tank reactor type, complete mix or plug flow, has different effects on the OTE. The plug flow reactor will have a higher concentration of pollutants in the beginning of the process that decreases the alpha value and increases the potential for fouling. As the concentration of pollutants decreases along the length of the reactor, the alpha values will increase and the potential fouling will decrease. Complete mix reactors have a uniform alpha value and fouling within the tank. A complete mix tank uses more air compared to a plug flow tank meeting the same effluent quality because the volume of the complete mix tank must be larger.

Processes Selection: Low Food/Biomass Ratio (F/M Ratio) or high solids retention time (SRT) processes tend to have a higher alpha value compared to high F/M ratio or low SRT processes.

Diffuser Layout: After choosing the alpha for each aeration zone, the airflow calculation can be performed. The number of diffusers required per zone can be calculated using an airflow to diffuser ratio at a specific design scenario (i.e. max month). Then the ratio is checked against other scenarios to make sure it is within the design guidelines of the diffuser type. The airflow per diffuser ratio and diffuser density may change the SOTE, so the calculation should be re-analyzed after completion of the diffuser layout.

If possible, it is recommended that a calibrated dynamic activated sludge model is used to calculate the airflows using the diffuser transfer

IMPROVED AERATION EFFICIENCY THROUGH DESIGN AND CONTROL

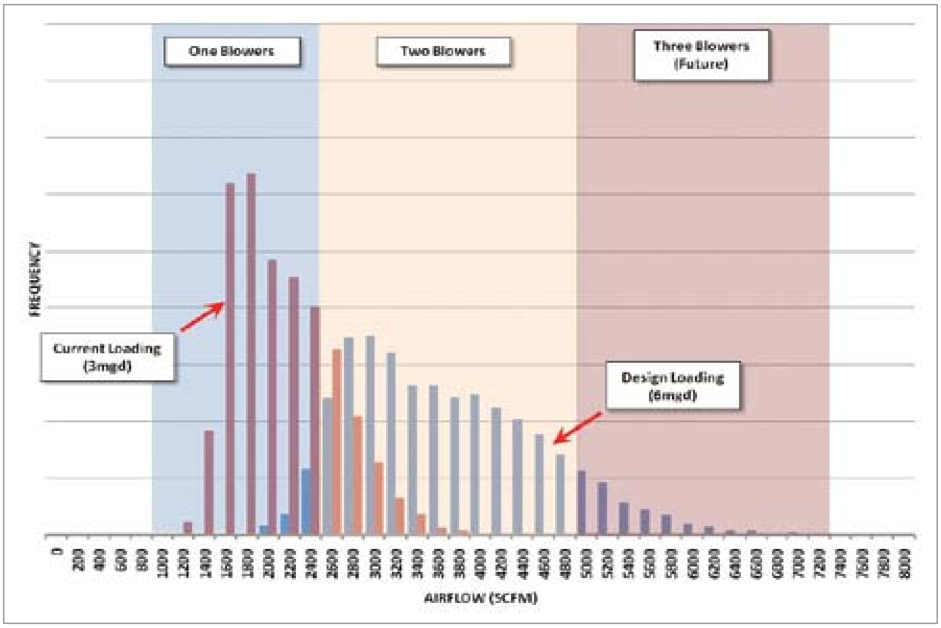


Figure 2: Airflow histogram with blower range.

efficiency parameters and layout. The results from the simulation will provide the complete range of airflows needed for analysis. Airflow can be analyzed by creating a histogram of the data, and calculating maximum and minimum month and day values at current loadings and design loadings. Figure 2 is an example of a histogram chart of airflow at a biological nutrient removal facility. The histogram allows the user to locate potential data outliers, and shows the complete airflow range required for the aeration system piping, control valves and blowers.

Process Piping

The sizing of the piping system is the next step after the airflow range has been determined. If the pipes are too big, the aeration system may be difficult to control. Likewise if the pipes are too small, the potential head loss may require larger horsepower blowers.

Calculating the pressure drop within the aeration piping system can be accomplished using a spreadsheet using the Darcy-Weisbach method as described in Flow of Fluids Technical Paper 410. For more complex aeration systems with several control zones, it is recommended that piping design software be used, such as Flow of Fluids by Engineered Software Inc., Lacey, WA. The software has an easy to use interface, can also be used to size the control valves, and can be applied to both airflow and water piping systems.

Blower Selection and Sizing

The selection and sizing of the blower system is the next step. The total airflow and pressure requirements were calculated during the sizing of the piping, control valves and diffusers. Blower power is directly related to airflow so it is essential for the blowers to supply the required airflow range during both current and future loadings. To meet the broad range of airflow requirements, adequate blower turndown is needed. Turndown can be accomplished by installing multiple blowers with turndown capabilities. All blowers have limited turndown, some better than others. Blower turndown depends upon how the turndown is accomplished (e.g. VFD, inlet valves). The use of the airflow histogram can help determine the number of blowers and the required turndown. A blower range overlaid on the airflow histogram is shown in Figure 2. It is important to note that there is a required airflow operation overlap between blowers to allow easy transition between blowers turning on and off.

Aeration Control System

Excessive and inadequate aeration can lead to operational problems for the treatment process efficiency and settling. Inadequate aeration during high loading can lead to ineffective treatment of ammonia, and increased SVI due to low DO sludge bulk. Excessive aeration can also lead to higher SVI because of floc breakup. Process control is the only practical way a well designed activated sludge system can effectively be manipulated to meet

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> — Matthew Gray, Senior Process Engineer and Steve Kestel, Lead Systems Engineer, BioChem Technology, Inc.

treatment goals, satisfy oxygen demand, minimize operational problems associated with inadequate or excessive aeration, and minimize aeration energy consumption.

The successful application of an aeration control system is dependent upon the successful integration of control system components. Control system components must be correctly sized and installed to insure successful operation. Each aeration control zone should have the following equipment and control components:

Equipment Components

Air Control Valves: The valves need to be sized to operate between 30 to 70% open. Below or above that range, the control valves become difficult to control. The valves should also be installed downstream of the air flow meters to minimize airflow disturbances.

Air Flow Meters: There are several different types of airflow meters in the market (i.e. mass flow rate, orifice plates, etc.) Each work well when installed correctly. All airflow meters require a minimum setback distance upstream and downstream of a disturbance to allow accurate readings. Review and apply the manufacturer's airflow meter installation guidelines.

DO Meters: The optical-based DO meters have become the standard at municipal WWTPs in recent years due to reliable readings and limited maintenance required or the device. The DO meters should be installed half way to two-thirds of the way down the length of the aeration control basin.

Control Components

Air Flow Calculation: The airflow calculation is the amount of air change required to bring the DO reading back to DO set-point. There are two methods used for calculating the airflow: Proportional-Integral (PI) control and Deterministic algorithm:

PI Control is a common feedback controller widely used in industrial control systems. The controller uses the proportional and integral values of the difference between the DO set point and reading to calculate airflow change. PI controllers are meant for linear-type systems. When PI control is used as aeration

IMPROVED AERATION EFFICIENCY THROUGH DESIGN AND CONTROL

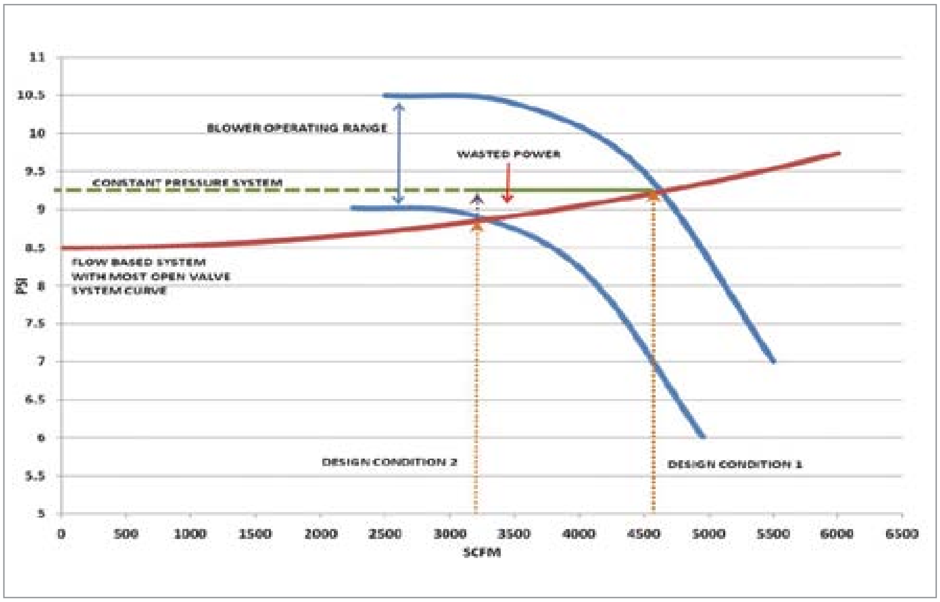

Figure 3: Pressure versus flow-based blower control.

control, which is nonlinear, the controller needs to be detuned for stability purposes.

Deterministic algorithm is a feedback control approach for calculating the required airflow change based upon a model of the aeration system.

Blower Control: The blower control adjusts the blower speed or inlet valves to supply the amount of airflow required to meet the DO set-points. The blower control can use pressure or total air flow to control the blower airflow change.

In a constant pressure system, the blower control is provided with an air header pressure measurement and an air header pressure set point, with the goal of maintaining the given pressure set point through the manipulation of either the motor speed or the inlet guide vane position. In operation, the blower control system responds to the increases and decreases in header pressure caused by changing air control valve positions, and the valve positioning algorithm opens and closes valves to attain an individual zone's DO or Airflow set point. It should be noted however, the pressure based system requires valves to throttle the blower back to attain the desired airflow. This is directly counter-intuitive from an energy savings standpoint, where it is generally accepted that operating at a lower system pressure yields greater energy savings. Traditionally, these savings can be realized through the implementation of a most open valve (MOV) control logic however this valve control scheme is incompatible with a constant pressure methodology unless additional logic is included to change the design pressure setpoint, adding to the complexity of the system.

The flow based blower control system requires first that an airflow target is set; this is usually accomplished through the use of a deterministic or model derived control approach. Once the airflow target is set, the blower is permitted to operate at any non-surge inducing VFD speeds and guide vane positions to attain the desired airflow.

As mentioned before, with this type of control methodology, MOV control schemes can be employed for additional energy savings and improved process flexibility as shown in Figure 3.

Aeration System Case Study

The methodology mentioned above for designing an aeration system was used for a project where a facility was upgraded to a 22,700 m^3/d (6 mgd) rated Modified Ludzack Ettinger process from the existing 11,350 m^3/d (3 mgd) rated sequencing batch reactor process. The project required a complete new aeration system including blowers, diffusers, and control equipment. The upgraded facility has been operational since May of 2010.

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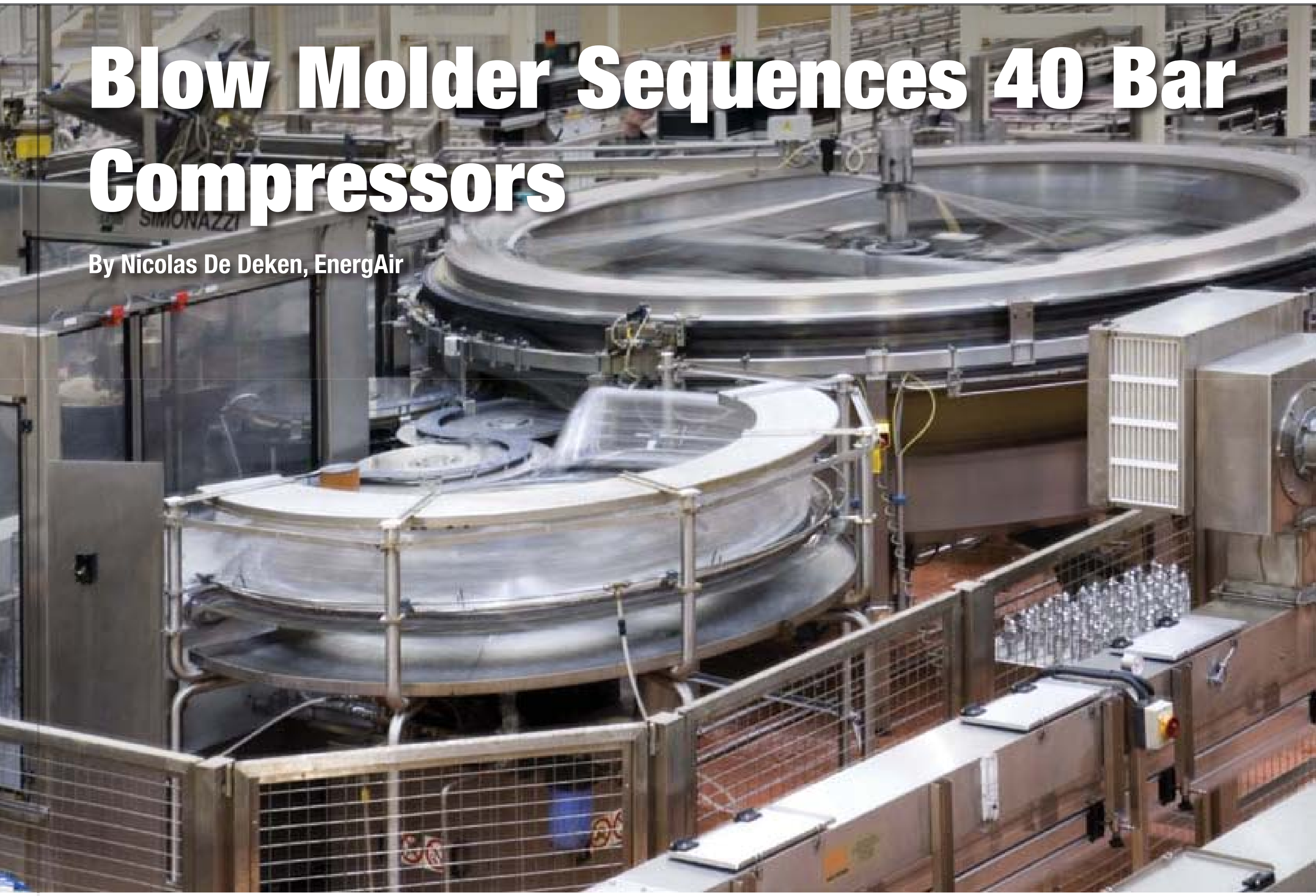

Blow Molder Sequences 40 Bar Compressors

By Nicolas De Deken, EnergAir

A recently completed energy efficiency improvement programme at the Britvic Beckton bottling plant has resulted in substantial energy savings and a positive impact on the company's carbon emissions allocation.

The program employed independent auditors to review and make recommendations on improvements to the high-pressure air generation system on site. The recommendations resulted in a new EnergAir control system for each existing piston compressor, the integration of a new compressor and the installation of an overall management, control and PC visualization package from EnergAir that provides integrated live control and reporting functions for the entire system, including the cooling, air preparation and building ventilation systems.

Kevin Cunningham, on the Britvic site management team comments, "Minimising the environmental impact of our operations is important to Britvic and reducing Energy Consumption is a key aspect of that policy. We were aware that a large part of our energy expenditure is in compressed air and commissioned energy auditors Air Compression Technology (ACT) to benchmark and audit the high-pressure compressed air system during October 2004. ACT collated all the operational data, analyzed it and then met with us to discuss the plant operational requirements in detail. From this meeting we were able to establish accurate estimates for the possible savings and create a clear strategy for delivering and maintaining tangible energy, cost and carbon savings."

Graham Coats, Director of EnergAir Solutions Ltd, adds "PET bottling plants tend to work on far higher pressures than normal automated production lines, typically 40bar as opposed to ~7bar, requiring more power and often providing a greater opportunity for energy saving. With the recent rises in energy costs and the experience we had gained form systems we have completed on other PET

plants, we were confident significant savings could be realized."

Kevin Course, of Air Compression Technology Ltd, the independent Site Auditor, "Importantly from the client's point of view the results are also highly measurable; we now remotely collate data on a weekly basis from the on-site EnergAir communications module. The data is analyzed and reported back to the client on a quarterly basis. The reporting and ongoing support from ACT Ltd. ensures that Britvic is able to continually maintain optimum efficiency levels (measured in input kW against output m3/min) regardless of any future change in their compressed air demands."

The table below summarizes the improvement in system performance since the introduction of the compressor management/control system. The system has achieved the energy gains by optimizing the installed compressor set, stabilizing the system pressure and allowing a careful but precise reduction in the system operating pressure. Further energy gains are expected in the short term through effective management and further fine-tuning of the system.

	KPIS	RESULT
1	Generation efficiency	Improved on average by 5.46%
2	Cost per delivered m^3	Decreased on average by 5.26%
3	Annual generation costs	Decreased by 29.36%
4	Annual kWh used	Net saving of 1,797,131 kWh
5	Net annual carbon saving	Saving of 772 tons

Note: All summary calculations are based on the cost per unit of electrical energy @ £0.032/kWh and is based on the system being operational for 8,400 hours/annum.

This installation also presented a number of practical challenges for EnergAir to overcome, not least that the original control cabinets for the four original high-pressure reciprocating piston type compressors had to be replaced in order to update to the new control technology. A recently installed fifth compressor was also integrated into the system and only required the replacement of its PLC controller.

Graham Coats, "The EnergAir SX unit manages the sequencing and duty cycles of the compressors, but because the original solid state controls did not afford any of the connectivity or fine tuning required to optimize the system, we built a new state-of-the-art compressor controller for each compressor. The new controls allowed us to fully utilise the variable load capability of the compressors and sequence the different sizes of compressors on site to match demand in the most efficient combination possible. The control installation included new cabinets, I/O modules, an Airmaster machine controller, user interface panel LCD HMI, terminals, switchgear, cabling and commissioning."

The previous control system required a complex sequenced start-up and shutdown procedure that required a long list of checks and switches to complete. Now, the process has been automated to the point where a single physical start button pressed either locally or on virtually the PC will carry out the complete timed and sequenced start routine including all the parameter checks and power switching. This improvement not only saves time for the operating crew, but it also contributes towards increased plant safety.

The compressor control elements were supplied by (EnergAir sister company)

BLOW MOLDER SEQUENCES 40 BAR COMPRESSORS

CMC Controls based in Belgium, one of the world's leading suppliers of onboard compressor machine controllers and custom compressor control HMIs. Once installed, the energy savings are derived from applying a combination of system pressure optimisation principles, matching air generation closely to demand, ensuring compressors are working at their optimum efficiency and only running when they are needed.

Air pressure sensors are fitted throughout the system and used to feed live data into EnergAir 'EnerSoft — Analysis' data manager software that is hosted on an onsite PC, this collates and records all the data and makes it available online to ACT Ltd. where it is compiled into specific Key Performance Indicator (KPI) reports. For day-to-day maintenance monitoring The complete compressed air system, from compressor, through to the dryers, cooling system and out across the plant is represented visually on screen in a Windows XP environment using EnergAir's EnerSoft – Visual software package, with key indicators such as system pressure and efficiency displayed clearly on screen as analogue style dials.

The data is updated every few seconds and so the information seen on screen is virtually live, Britvic are able to predict and plan for any changes made to the plant and report effectively on incremental positive changes made to keep efficiency maximized.

Kevin Cunningham, "The project has been judged a real success as we have achieved all our predicted goals for energy saving and improvement in control and reporting. The system will now continue to reduce energy usage and improve efficiency on an ongoing basis. Based on the success at Beckton other Britvic Group company plants are now also implementing similar carbon saving upgrades."

In an additional stage of process integration at the plant; the air dryers, compressor water-cooling system, and ventilation system are integrated into the overall management and optimisation package. A triplex dryer arrangement was installed and connected to the management system, valves on the discharge pipes are operated and closed based on the quality of air treatment — if a dryer goes into a fault state or changes to a high dewpoint mode, another dryer is started up, the valve on the unit that requires attention is closed and the airflow is directed to another dryer. The system will even automatically alert the relevant service provider that the dryer requires servicing.

The new process control system also monitors pressure and the dewpoint (air quality) at the point of entry into the bottle blowing hall, it monitors and meters the amount of compressed air delivered to each of the blowing machines, allowing Britvic to use the efficiency values and the line-flow values to cost each bottle blower precisely. The flow is held in the permanent memory of the EnergAir I/O box making the device both a reliable and tamper proof data logger.

Two additional control panels were built for the HVAC system, delivering the same style of fine control that has been applied to the compressors, and replacing what was again a crude, but standard ventilation and temperature control system. The water is pumped around the system and so more CMC control equipment was employed to manage the pump. Temperature and flow sensors were placed at key stages around the cooling system and inside the building; the feedback loop was then connected through a controller and to the extraction fans in both towers. The system optimizes energy usage, heats the building when required and is fully integrated into the control and visualization packages.

Graham Coats, 'the completeness of the system and the level of data logging at the plant provides an unparalleled level of diagnostic ability. Comparing data from different areas of the system, we can track down a fault far faster than would ever be possible using physical methods. Prior to the system being installed a potential fault could have been attributed to a huge list of potential causes, now however, being able to drill down into the individual machine controllers and view the data files of individual components, a problem can often be narrowed down to a single component or a very precise part of the process and solved with out it ever affecting overall production." BP

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THE SYSTEM ASSESSMENT

Analyzing Interval Data to Establish Compressed Air Flow

By Hank van Ormer, Air Power USA

Energy management requires accurate and repeatable measurement of critical data, which is easily monitored and analyzed as required to stimulate required action. When a compressed air system assessment is implemented, the basic minimum measurement protocol to establish the baseline (pre-measurement) and qualify and quantify the results (post-measurement) is often:

- Flow (scfm), pressure (psig), input power (kW)
- By individual air compressor
- For the whole air system
- Pressure dew point

This data trended and applied to the identified operating profile generates an accurate annual operating energy cost baseline and proposed modified operating cost. The post-measurement will then generate an accurate new baseline with the modified air system.

How Do We Get Data During a System Assessment?

Sometimes the data comes from the plant's current data acquisition system — if it is accurate (we often find current systems are old and/or basically out of calibration, etc.). What is most often the case, the assessment team installs temporary metering equipment. With this data, the operating health problems of the system are identified, the recommended changes implemented and the results measured and identified.

At the end of the assessment, these meters are often removed, yet the true objective of this whole exercise was not just to identify, implement, and create savings, but also to maintain these savings on a continuing basis throughout the future and even to improve on them. We call this "savings persistence" or "savings sustainability."

The main thought that should jump out here is: Why did we remove the measurement equipment that allowed us to identify the problem during the system assessment? Plants require the same or even a more complete measurement and monitoring system to give the operating personnel the ability to maintain the optimization profile and to continue to monitor and report the current situation with their compressed air system.

Plan to Leave the Flow Meters in Place!

On a recent audit at an appliance manufacturer, the pre-assessment meetings led to the plant purchasing insertion flow meters able to read and log (500,000 data points) accurately in "wet air" — along with pressure and temperature. The assessment team installed the meters in prepared locations and developed the data required for the complete pre- and post-measurement. At the end of the assessment project, the assessment team worked with plant personnel to complete the permanent monitoring and measurement system including reporting critical data to plant management on a continuing basis. Future plans will expand the monitor/measurement system.

Stabilizing the compressed air flow relative to identified compressed air demand now allows accurate measurement of true input energy savings for future projects such as lowering operating pressure, continued leak repair, shutting off air supply to equipment not in use and installation of air-saving devices.

Words of Caution When Using Air Compressor Input Power (kW) to Estimate Compressed Air Flow

A significant percentage of compressed air system assessments estimate compressed air flow use, in the plant, by using air compressor input kW measurements. Estimating air flow, from basic air compressor

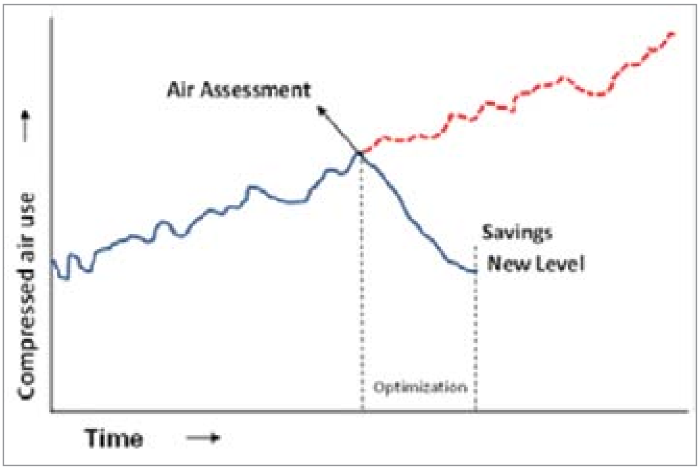

Figure 1. Projected operational energy savings after a system assessment and project Implementation using measurement instrumentation.

performance input kW at actual pressure, can be used to estimate the scfm flow from an air compressor when the accurate OEM operating data is available, particularly in positive displacement compressors. It's important, however, to understand when this method can go wrong.

When relying on kW to estimate the flow at the discharge pressure, be sure to evaluate:

- How is the kW measured? Check the known measurement against a calibrated motor analyzer (such as a Fluke 41 or 43)
- Identify by measuring each leg for amps, volts, power factor, etc. Determine all the legs are in balance and what is the estimated motor efficiency

It is important to realize that there are other things that can cause higher kW — in addition to the direct work utilized in producing the compressed air flow at discharge pressure.

Figure 3 shows the measured kW of two identical air compressors and identified a significant disconnect problem. These two identical 300 hp

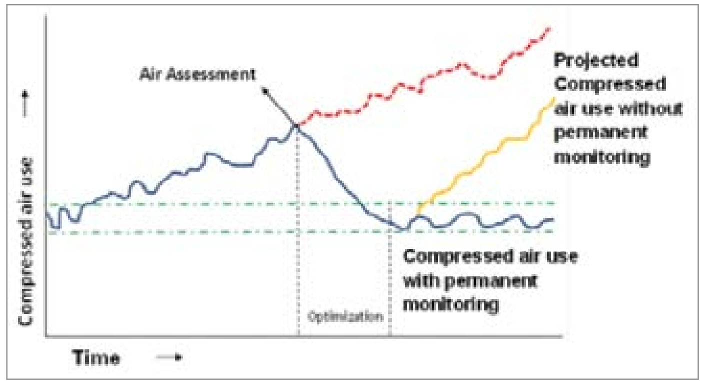

Figure 2. Achieving "Savings Sustainability". Compressed air usage with effective use of permanent measurement/monitoring.

class units were installed next to each other (full load rated input kW at 100 psig = 225 kW each). Unit #2 consumed 215 to 225 kW — that was OK. Unit #1 consumed up to 325 kW — up to 100 kW more than Unit #2! Unit #1 had been running this year for seven years. At $48,000 per year of extra energy cost, this represented $336,000 of wasted energy. The reason was a problem on the disconnect. Other

THE SYSTEM ASSESSMENT

Analyzing Interval Data to Establish Compressed Air Flow

issues can cause the kW number to not accurately represent flow such as motor rewinds causing deteriorating efficiency and connective wiring issues. In this example, if this kW number had been used to represent air flow, it simply would have been false.

The Data Sampling Interval, of kW, is Critical

Step-controlled positive displacement compressors deploy either 2-step, 3-step, or 5-step capacity controls. Trended data can be used to identify the time frame for both loaded and no-load periods and identifying the percent of flow for each unit. Again, using the air compressor rated performance data for full load acfm/scfm flow allows this method to generate a relatively accurate flow volume for the trended condition. This method also has to be implemented with care.

Whenever the protocol calls to generate a flow volume estimate at pressure from input power data, the data point sampling interval is very critical. Any time logged data is used for diagnosis, as opposed to establishing averages as in the case of "step-type" capacity controls, the sample rate must be close enough to be sure every cycle point is included or the result will not accurately reflect the load/unload profile, and therefore, the generated flow data will be skewed. It should be noted that when using kW to project probable flow, kW should be measured directly reading amp, volts and power factor simultaneously.

The chart in Figure 4 shows data taken, at the same time, with a 30-minute sampling rate between data points for six 400 hp, two-stage, double-acting, water-cooled XLE compressors with 5-step unloading (100%, 75%, 50%, 25%, and idle) over a 24-hour period. Usually 3-4 units run at any one time and they are set to load in sequentially. The scfm (flow) is calculated by the control monitoring system using the percent of time at load. With the 30-minute intervals, the number of part load units on at any one time is not evident and you cannot see the various levels of unloading as a percent of full load of any unit. The cycling rate is much too fast for the sample rate.

The chart in Figure 5 is the same data, with a 5-second sampling rate, over a 6 hour period. Reviewing the curves produced by each of these during the same 6 hour period reveals:

- The 5 second data point chart clearly shows the 5 step unloading for each applicable unit

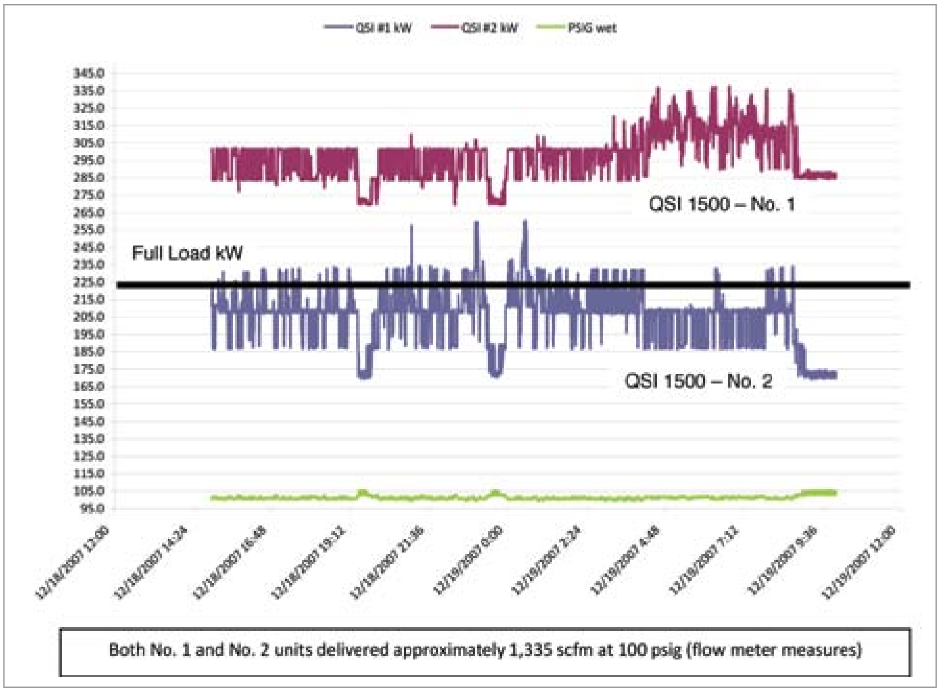

Figure 3. Both No. 1 and No. 2 Units delivered approximately 1,335 scfm at 100 psig (flow meter measures).

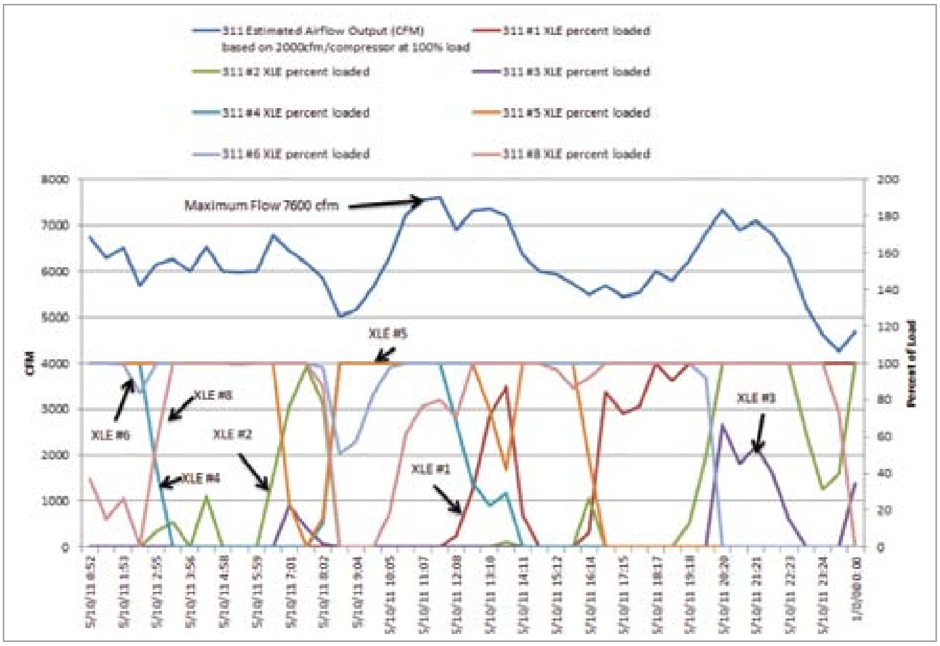

Figure 4. 30-minute data sampling interval of six 400 hp air compressors.

- The minimum calculated flow with the 30 minute data points was 5,000 cfm. The more accurate minimum flow with the 5 second data points was 6,000 cfm
- The maximum flow calculated with the 30-minute data point was 7,600 cfm for a very short duration. The maximum flow, using the 5 second sampling rate, is 8,000 and occurs ten separate times during the six hours of logging and one time for over a 20 minute sustained duration

To conclude, the protocol to *correctly* identify input power (kW) and interpret the data per situation and to identify the air flow is correct. Proper implementation depends on personnel familiar with the specific air compressors and

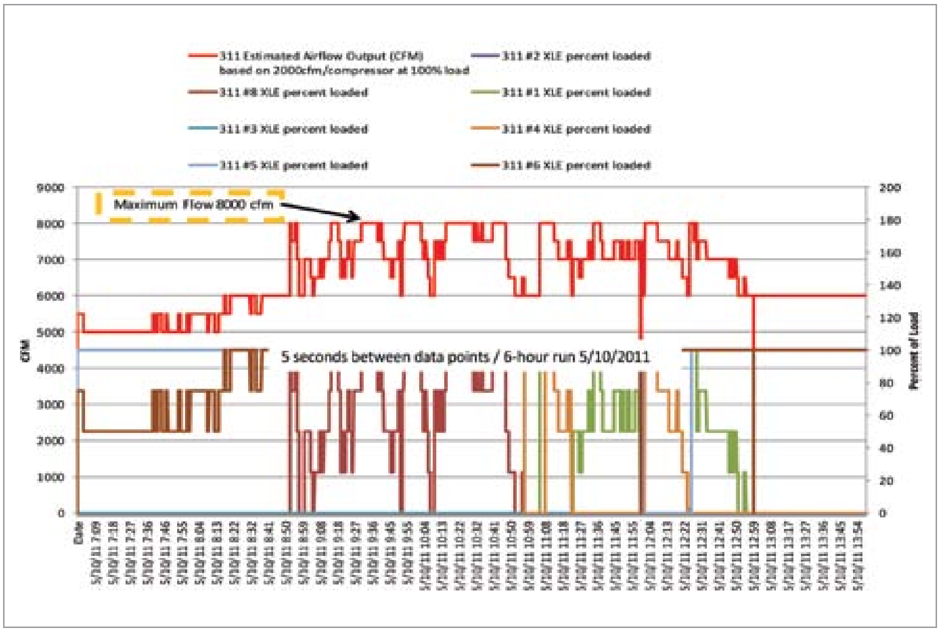

Figure 5. 5-second data sampling interval of six 400 hp air compressors shows different results.

THE SYSTEM ASSESSMENT

Analyzing Interval Data to Establish Compressed Air Flow

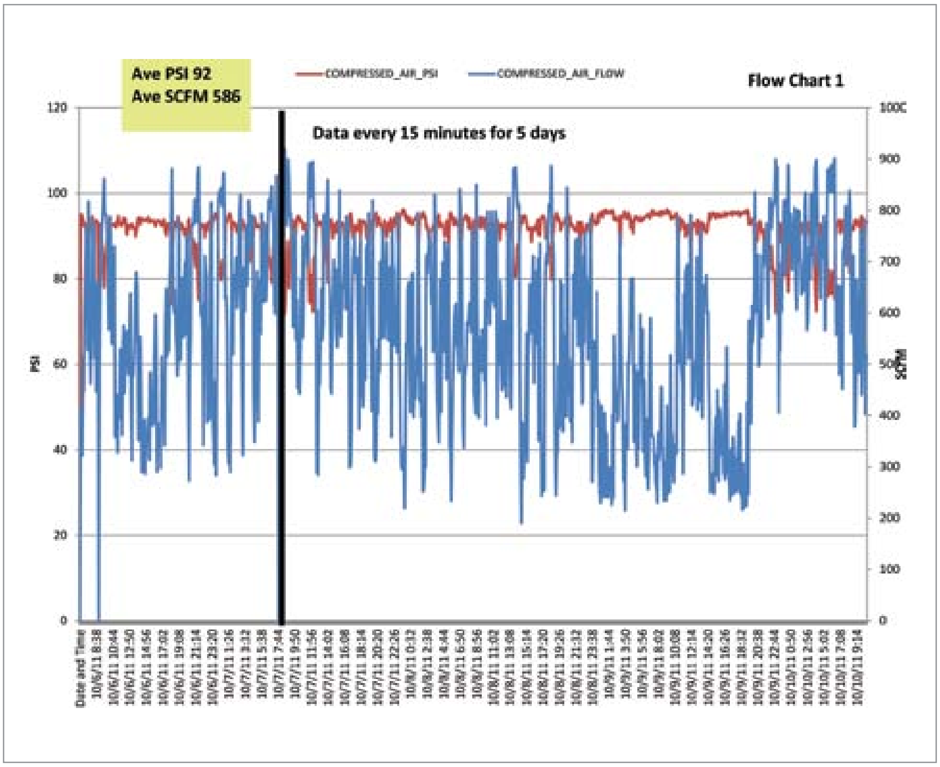

Figure 6. Flow Chart 1 represented an average flow of 586 scfm at 92 psig.

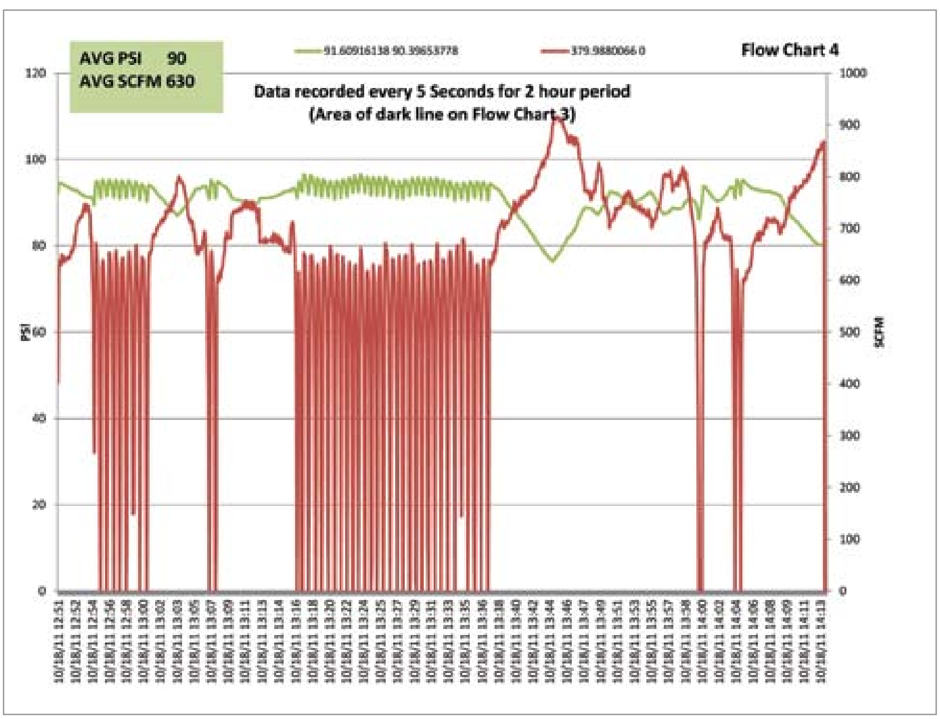

Figure 7. Flow Chart 4 represented an average flow of 630 scfm at 90 psig pressure.

the operation of the specific capacity controls — along with the knowledge and experience to properly acquire and process the data.

Interpreting Flow Meter Charts

As discussed, with kW measurement, it is important to be able to read all critical data to analyze what is or is not occurring. This is often dependent on data point times when logging data with trended measurement. The measurement interval can provide significantly different data when trying to determine maximum sustained peak flow — i.e. any flow that will have to be supplied or the system will fall in pressure to ineffective levels. This is a function at peak flow, duration at peak and available effective storage. Care must be taken.

We provide an example of the same installation where we installed flow meters, during the system assessment, and created four flow charts with different measurement intervals.

- Flow Chart 1 (Figure 6) represented five days of measurement with data points plotted and averaged every 15 minutes. Conclusion: an average flow of 586 scfm at 92 psig. There are apparent short duration flow peaks up to about 900 scfm.

- Flow Chart 2 represented 16.5 hours of measurement with data points plotted and averaged every 5 seconds. Conclusion: an average flow of 618 scfm at 92 psig pressure. The pressure at one point is below 92 psig for over 6 hours out of the 16.5 hours. Furthermore, the pressure fell to below 85 psig for over 1 hour and below 90 psig for almost 5 hours. There are several sustained peak demands in this short time, one of which is 90 minutes long at or near 900 cfm.

- Flow Chart 3 represented 17 hours of measurement with data points plotted and averaged every 1 minute. Conclusion: an average flow of 536 scfm at 93 psig pressure.

- Flow Chart 4 (Figure 7) represented 2 hours of measurement with data points plotted and averaged every 5 seconds. Conclusion: an average flow of 630 scfm at 90 psig pressure.

After reviewing Flow Charts 1 through 4, this operating profile is now much more detailed. Enough time must be logged and plotted, even with flow meters, to allow not only these important pieces to become visible, but also to allow the profile to be compared to apparent demand activity and ensure the charts only reflect plant flow demand and not piping or external issues. Further observations made from Flow Chart 4 were:

- At 13:20 the pressure began to fall as the demand increased
- By 13:27 (after 7 minutes) the pressure had fallen from 93 to almost 75 psig while the demand increased from about 615 scfm to almost 950 cfm
- The flow demand stayed above 800 scfm for over 3 minutes
- During this 24-minute run the pressure never returned to 93 and generally was well below 90 psig
- If production was not negatively affected by the *sustained low pressure,* for almost 24 minutes, then it may be most likely the plant can and could run at a lower pressure
- It would be a good idea for plant personnel to identify this 300-400 scfm event, particularly if it shows up in a continuing manner. Perhaps action can be taken to eliminate some of this and/or convert the peaks to low average flow by some ingenious use of storage. Flow chart 4 does not tell all, but it does identify probable areas of opportunity to be fully investigated.

Conclusion

The key to compressed air system measurement is to produce verifiable, repeatable and sustainable data and results that can not only be used to reduce energy costs but to sustain the savings. After a full audit is completed and implemented, establish an ongoing monitoring program that will allow the plant to maintain your optimized savings by:

- Tracking air system efficiency to maintain savings levels ("savings persistence")
- Help identify energy projects and document savings to collect utility rebates
- Troubleshoot, find and diagnose air system problems, leaks and bottlenecks
- Allocate compressed air system costs at the department level based on consumption measurement for individual departments and at key points of use BP

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APPLYING VARIABLE SPEED COMPRESSORS IN MULTIPLE COMPRESSOR APPLICATIONS

Application Success Stories and Improvement Stories

Continued from page 17.

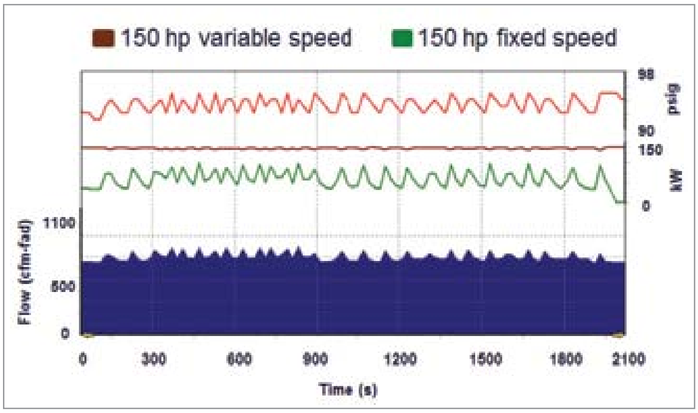

Figure 7: Control gap example 2 sample operation.

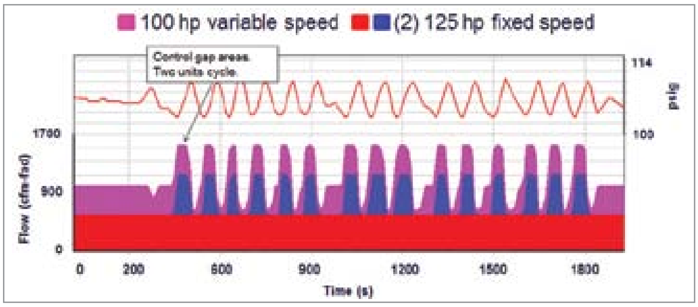

Figure 8: Control gap example 3 highlight.

The two fixed speed compressors are both rated for 497 cfm-fad at 110 psig and therefore fit within the control range of the variable speed compressor. As can be seen in Figure 5, the system can provide a steady operating pressure throughout the flow range of the system as long as the system is properly controlled with a master controller.

Control Gap Example 1: Same Sized VFD and Fixed Speed Compressors

Figure 6 shows a system which exhibits a control gap between the variable speed compressor and one base-load compressor. In this system there was one fixed speed 350 hp compressor, one variable speed 350 hp compressor, and one 200 hp fixed speed compressor. This system did not have a master controller for all the compressors. Figure 6 highlights a period where the medium load unit (200 hp fixed speed compressor) was operating fully loaded. This consequently resulted in multiple periods where the variable speed compressor and the same sized base-load compressor were cycling between load and unload together producing a fluctuating pressure of 8 psi and an uncharacteristically high specific power (kW / 100 cfm) for the facility.

Master Controller Benefits

With a properly selected master controller for all compressors available, the 200 hp fixed speed compressor would only load during lower production periods and the 350 hp variable speed compressor would trim. The master controller would transition the 200 hp fixed speed compressor off when higher production periods occurred, allowing the 350 hp fixed speed compressor to run at full load and the 350 hp variable speed compressor to trim. This would operate the station more efficiently at each possible production level.

Control Gap Example 2: Same Sized VFD and Fixed Speed Compressor

Typically, with a same sized variable speed compressor and base-load compressor, the variable speed compressor is operated as the first-on compressor. This usually ensures the facility will have the best potential energy efficiency during off-production periods. However, during peak production without a master controller, and the compressors operating in a cascade control, the variable speed compressor can run fully loaded with the base-load compressor trimming resulting in higher than normal specific power. This can actually increase operating costs, and will result in a fluctuating plant pressure. Figure 7 shows a 150 hp fixed speed compressor operating as the trim compressor, and the 150 hp variable speed compressor operating 100% of full load.

Since the variable speed compressor control range is smaller than the fixed speed compressor there is an inherent control gap within the station. The variable speed compressor could operate as the trim load unit during peak demands with the installation of a master controller; however, the benefits of the variable speed at lower demands may not be realized. With the variable speed compressor as the base-load and the fixed speed compressor as the trim-load compressor, the facility is spending 20% more in energy than a system with one 150 hp variable speed compressor, one 75 hp fixed speed compressor, one 150 hp fixed speed compressor, and a master controller. The master controller would properly select all existing units to match supply to demand while maintaining a stable operating pressure rather than a fluctuating system

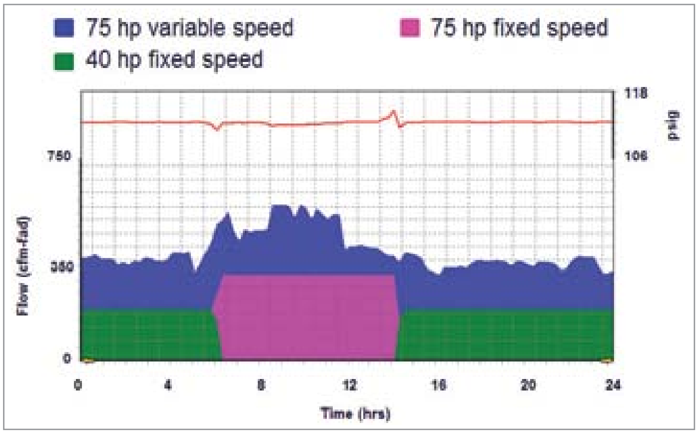

Figure 9: Properly designed system with master controller.

> "An overall cost analysis can be completed to determine the return on investment by adding a variable speed compressor(s) to the system as opposed to other alternative solutions."
>
> — Neil A. Mehltretter, System Design Manager, Kaeser Compressors, Inc.

pressure, and the 75 hp fixed speed compressor would fit within the control range of the 150 hp variable speed compressor thereby avoiding the control gap.

Control Gap Example 3: Larger Fixed Speed Compressor with Smaller VFD Compressor
With a smaller sized variable speed compressor and a larger base-load compressor typically the variable speed compressor is operated again as the first-on compressor. This operation ensures that the facility will have the best potential energy efficiency during off-production periods, as long as the variable speed compressor is large enough to meet demand alone. However, during peak production, when the demand is higher than the supply of the variable speed compressor, the base-load compressor will be needed. This often results in more than one compressor loading and unloading almost simultaneously, and the compressors fighting each other for control of the station; again increasing the specific power and increasing the overall cost of operation of the plant.

Figure 8 shows a system with two 125 hp fixed speed compressors, one 100 hp variable speed drive compressor and highlights a period where the control gap between the variable speed compressor and the fixed speed compressors is evident. In this case, one 125 hp fixed speed compressor is fully loaded, which is a good practice. The demand increases slightly and therefore the 100 hp variable frequency compressor loads to trim. However, since the variable speed compressor was not large enough to handle the entire increase in demand, the second 125 hp fixed speed compressor was subsequently loaded. The additional supply flow from both the 100 hp and the 125 hp compressors was too much for the demand and both compressors subsequently unloaded. The process continued and the specific power of the station became less efficient, as well as the increased wear on the units from constant cycling.

In this particular scenario, adding a 75 hp fixed speed compressor along with a master controller to the existing fixed speed compressors and variable speed compressor would avoid the control gap and balance the system by maximizing part load power efficiency of the station.

Avoiding Control Gap

Properly Sized Equipment
Figure 9 shows a system sized based on a demand profile to avoid any control gaps within the demand. The system included a 75 hp variable frequency drive compressor, a 40 hp fixed speed compressor (medium load unit), and a 75 hp fixed speed compressor (base-load unit) with a master controller. The master controller properly selected between the two differently sized fixed speed compressors to operate fully loaded while the variable frequency drive compressor trimmed.

APPLYING VARIABLE SPEED COMPRESSORS IN MULTIPLE COMPRESSOR APPLICATIONS

Application Success Stories and Improvement Stories

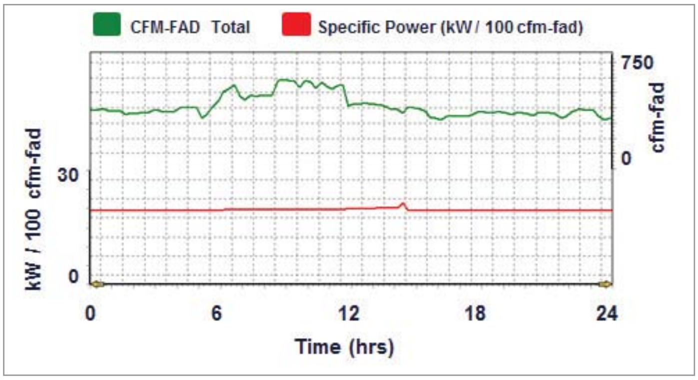

Figure 10: Flow and efficiency for properly designed system.

Compressor	Size [HP]	Control Type	Load [kWh]	Idle [kWh]	Total [kWh]	Duty Cycle [%]
K1	75	Fixed Speed	30,444	186	30,630	99.4%
K2	75	Variable Speed	23,120	0	23,120	100.0%
K3	40	Fixed Speed	4,445	48	4,493	98.9%
Total:	190	-	58,009	234	58,243	-

Table 1: Sample monthly energy consumption and duty cycles for properly designed system.

The addition of the medium load unit avoided the inherent control gap between the two 75 hp compressors. Along with the master controller, the station provided a relatively stable operating pressure throughout the various demand levels while maintaining an efficient specific power throughout this sample day of operation. Figure 10 highlights the consistent specific power over an entire sample day regardless of the demand profile. The only mild increase in specific power occurred during a transition to a lower supply range which represents a relatively small percentage of operation.

This type of operation results in a low specific power, a low overall energy cost due to the compressors spending little time cycling between load and unload, as well as little time idling. Table 1 shows a one month sample for the system discussed. All three units have a duty cycle close to 100%, meaning that the idle costs are less than 1% of the overall energy consumption. The added benefit will be lower maintenance costs to the cycling components of the individual compressors as well as stable plant pressure. Adding a third 75 hp fixed speed or variable speed compressor would provide complete redundancy to this station and would be highly recommended.

Summary and Conclusions

In all of the examples shown, the systems which were sized properly based on a demand profile, and operating on a master controller provided the lowest energy consumption and most efficient station operation regardless of the demand. The systems which were either not sized based on a demand profile, did not include a master controller, or were not sized appropriately resulted in a higher than expected energy consumption, higher overall maintenance costs, and the appearance of less stable operating conditions by plant personnel.

Key Points:

1) In typical industrial applications, several compressors supply the total flow.

2) Multiple compressor systems should be controlled by a master controller to operate in different combinations and operating points or operational modes.

3) In such installations, an individual compressor follows the control scheme of the master controller and does not independently respond to or reflect changes in systems demand.

4) The combined operation of fixed speed and variable speed compressors allows the controller to use the individual advantages of each type of compressor to its full extent and avoid the disadvantages to achieve high system efficiency by decoupling the compressors from the actual demand.

5) The proper design of a compressed air system and the choice of compressors cannot be done without first determining the demand profile.

6) The design may include multiple variable speed compressors, one variable speed compressor or none at all depending on the prevailing demand profile and other mitigating factors such as capital cost, return on investment, and application.

AUTHOR'S BIOGRAPHY

Neil Mehltretter has a Bachelor's Degree in Chemical Engineering from The University of Florida. Neil first worked on energy efficiency projects during his time at The University of Florida, and after graduation, he worked in the alternative energy industry before joining Kaeser Compressors, Inc. in 2004. Neil is a Master Certified System Specialist through Kaeser's Factory Training Program and has completed the Compressed Air Challenge Level 1 and 2 training courses. Neil is also a Qualified AIRMaster+ Specialist. During his time with Kaeser, he has supported numerous compressed air projects and air audits as well as served as the primary contact for the installation of Kaeser's master controller, the Sigma Air Manager. Currently Neil manages the design and engineering services for Kaeser, which includes energy improvements as well as compressed air selection. He can be reached by email at neil.mehltretter@kaeser.com.

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IMPROVED AERATION EFFICIENCY THROUGH DESIGN AND CONTROL

Continued from page 23.

During the design process, GPS-X was used to simulate the required OTR needed for the design, using historical influent data and supplemental diurnal sampling. The OTR data and minimum required alpha and SOTE were forwarded to the diffuser manufacturer to optimize diffuser layout design.

After the diffuser design was complete, GPS-X simulation was modified with the diffuser information and the range of airflow required to meet the oxygen demands was calculated.

Three types of blowers were analyzed, Tri-lobe positive displacement, multi-stage centrifugal, and high speed direct drive turbo. Tri-lobe positive displacement blowers with VFD for speed control were selected based upon a 10 year present value cost analysis and the turndown capability. The final design allowed provisions for the installation of five total blowers. The blowers have a turndown of 60 to 70% with VFD control, which allows great operational flexibility.

The aeration control system consists of four control zones in each train, with each control zone having an air control valve, air flow meter, and DO meter. The aeration system equipment is controlled by the Bioprocess Aeration Control System (BACS).

BACS Description

The aeration control system uses airflow, temperature, DO measurements, and oxygen saturation to calculate an oxygen uptake rate factor (OURf) in each zone. The OURf can be used to trend the actual OUR within the aeration control zone.

Airflow Calculation Technique 1: Predictive Feedback Control

The calculation of the airflow set point is based upon the weighted average of two techniques of calculating the required airflow to meet the DO set point. The first technique is considered predictive feedback control which uses two methods of using the OURf to calculate the airflow set point. The second technique is a feed forward method that uses ammonium measurements to calculate the change in OUR based upon loading.

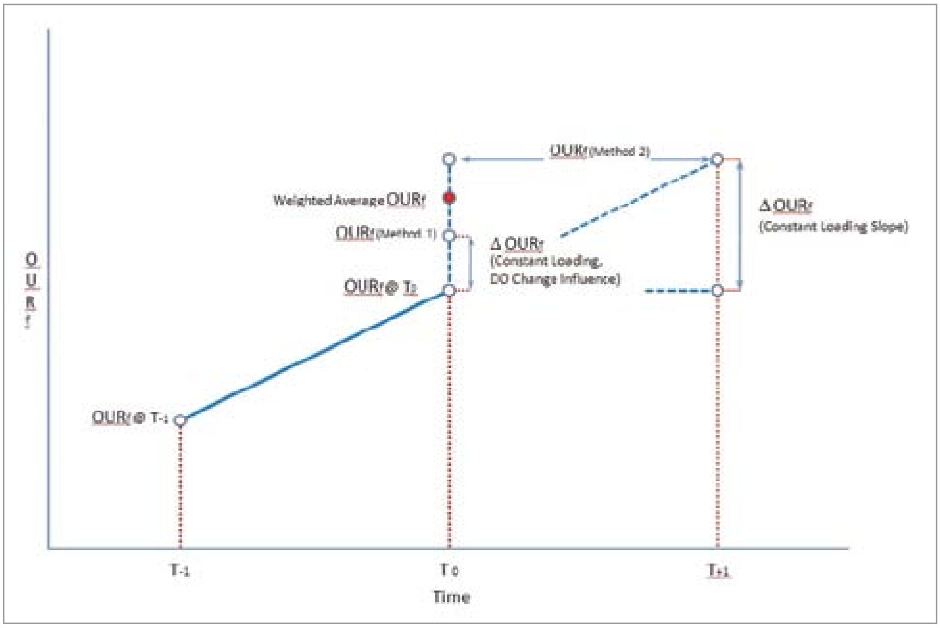

Figure 4: Graphical depiction of OURf airflow calculation methods.

Method 1: It is assumed that the loading does not change from control time steps T0 to T1, and the change in OUR is due to the required change in DO to match the set point. The concept is that the reaction rate changes with the DO concentration based upon the Monod kinetics.

Method 2: The method consists of predicting the OURf at time T1 based upon the previous increase in OURf from time T-1 to T0.

Airflow Calculation Technique 2: Feed Forward Control

The two OURf values calculated in the predictive feedback technique are averaged based upon a ratio of the two. The default value ratio is 30% Method 1 and 70% Method 2. The airflow is then calculated using the weighted average OURf. The calculation of airflow is a function of temperature, DO set point, and oxygen saturation. A graphical description of the two methods is shown below in Figure 4.

A challenging aspect of providing a stable and robust aeration control system is the proper response to process disturbances. The most direct way to accomplish the goal of the control system is to first quantify the influent load by strategically locating 'loading sensitive' in-situ instrumentation at the beginning of (or directly before) the first oxic zone and then preemptively responding to this information before the load disturbs the oxic zone's DO reading. Because an accurate BOD/COD loading measurement cannot be collected in real time, an online ammonia analyzer can be utilized as an indirect indicator of BOD/COD loading. To do this, first one must correlate BOD/COD concentrations with ammonia concentrations throughout the day. Tests on the influent for both BOD/COD and ammonia concentrations performed at different points throughout the day allow for the establishment of such a first-order proportional relationship.

Once an estimate for the current oxygen demand of the influent is gauged, this information is processed by an algorithm based on the Activated Sludge Model (ASM) to estimate the current OUR and the proper airflow rate required to correctly compensate for any changes in the OUR in the incoming wastewater since the last control calculation.

Airflow Set Point

As mentioned above, the calculation of the airflow set point is based upon the weighted average of the predictive feedback and feed forward techniques of calculating the airflow required to meet the DO set point. The ratio of the weighted average is dependent upon field verification of the feed forward model. In the event that the ammonia signal is low quality, lost or not used, the system's backup control formulates the proper control response by applying only the predictive feedback control technique.

Valve Control

At regular intervals, the aeration control system sends a total airflow set-point to the blower control, and then positions the air control valves to distribute the air to each aeration zone based upon the calculated airflow set point for each zone.

The valve positioning logic uses the actual individual butterfly valve's Cv curve to calculate an approximate new valve position to satisfy the airflow set point. After giving the valve control logic a sufficient amount of time to adjust to the desired airflow, the valve locks in to a final position to prevent unnecessary additional starts of the actuator for the remainder of the control cycle. When a new air flow set point is calculated the valve lockout is lifted and the control logic restarts.

The valve control includes dynamic most open valve logic to promote low system pressure by having one of the control valves become the most open valve (MOV) at 85% open and allows the other control valves to seek their position to meet the airflow requirements. When a control valve that is not the MOV is calculated to be at greater percent open than the MOV, then that valve becomes MOV, and the previous MOV will be able to close.

Advantages

The process-based control concept allows the aeration control system to respond accurately to any changes in the operating conditions and influent loading. It differentiates the aeration control system from a PI control loop that has a fixed gain independent of the process changes, so outside of a narrow band for which it is tuned, the PI controller will either over- or under-react to daily and seasonally changing conditions. The system is self-tuning and stabilizes quickly after process disturbances.

The flow control of the blowers (as opposed to pressure control) has additional advantages. The system is not required to restrict the flow to maintain a constant pressure, so the most-open-valve logic of the aeration control system ensures that the blower is always operating at the lowest possible system pressure. It also prevents the often observed cyclical hunting of blower and valves that is caused by the blower control and valve control loops responding to the control action of the other control loop, instead of process changes, leading to unstable DO values and premature failure of the valve actuators.

RESULTS

The startup flow at the facility was at sixty five percent less than design, which could have led to wasted energy or process upset, but the designed flexibility of the system prevented any limitations due to low loading. The system has been able to meet the dissolved oxygen set-point requirements and control the dissolved oxygen to within 0.5 mg/l of the set point 94.5% of the time and within 1.0 mg/l of the set point 99.5% of the time. The measured aeration power savings is 41 percent compared to constant speed operation.

CONCLUSION

The Poinciana aeration system installation confirms that a successful application of an aeration control system is dependent upon a successful operation of aeration system components. System components must be correctly sized and installed to insure successful operation. By following the design procedures described in the methodology of the paper the implementation of a properly designed aeration control system can be achieved. BP

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STOP OPERATING BLIND — USE A FLOWMETER

By Ron Marshall for the Compressed Air Challenge®

Participants of Compressed Air Challenge's Fundamentals of Compressed Air Systems seminars are usually surprised to learn that compressed air is one of the most inefficient energy sources for machine operation in your plant. To gain about one horsepower of mechanical energy from a compressed air powered motor it costs seven times as much at the input of the air compressor. And surprisingly between 20 and 30 percent of this valuable power is lost even before it gets to the end use. Further to this another 10 percent is lost to artificial demand caused by higher than required pressure, and to top that all off, another 10 percent is wasted by equipment that is either inappropriately supplied with compressed air or left to consume air even when the associated production machine has been turned off.

These facts are surprising to people because their compressor rooms are notoriously lacking in even the basic instrumentation that could tell them the energy and flow characteristics of their system. Often large amounts of time and money are expended in optimizing the production side of a compressed air system, but the system operator has no idea if the new upgraded equipment is producing air as efficiently as expected or if that efficient produced air is wasted or misused.

Open Your Eyes

An old management axiom is: "If you can't measure it you can't manage it." This is still as true today as it was when it was first uttered by wise men many years ago. But in the old days, where compressed air was concerned, there may have been some good excuses for ignoring compressed air flow measurement. Years ago pretty much the only way to measure compressed air was to install orifice plate meters. These units introduced a pressure loss into the system, which was actually the way the measurement was done. The flow meter instrumentation of the time had to measure the plate pressure differential and equate this to a particular flow. Due to the square

"To gain about one horsepower of mechanical energy from a compressed air powered motor it costs seven times as much at the input of the air compressor. And surprisingly between 20 and 30 percent of this valuable power is lost even before it gets to the end use."

— Ron Marshall

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function characteristics of the pressure drop the meters could be accurate at higher flows near full rating, but as the flow decreased the rapidly diminishing differential pressure became too small to measure, resulting in poor turndown characteristics. These also meters had to be calibrated for a certain pressure and became inaccurate if the pressure changed. These meters introduced costly pressure differential into the system at high flow and had only limited accuracy for determining flows at low flows, where leakage rates are usually measured. Many older plants still have orifice plates still installed, many of which have instruments that are out of service, but the plates are still robbing the system of energy. If you have one it may me time to consider removal.

New Old Idea

In these modern days of low cost electronic instrumentation many new ways to measure flow have been developed. The most popular of these is the thermal mass flow meter. The principal of design of these meters was actually invented in 1914 by L.V. King who noticed that his hot wire anemometer measured the mass velocity at the point of flow. The meter works using two temperature sensors, one heated and the other static. Mass flow is proportional to the amount of power required to keep a constant temperature difference between these sensors in a flow of gas. Modern day thermal mass meters are inserted into a pressurized compressed air line using a number of different mounting strategies, including hot tapping. The result is an accurate signal output that is not affected by changes in air pressure. If the flow meter is calibrated for a given pipe size, and the probes properly positioned in a turbulence free airstream, an accurate flow profile can result with a typical turn down range of about 100:1. Thermal mass meters suffer from an important issue, they need to be placed in a airstream that is dry, the presence of free water interferes with the proper display of flow due to the much higher cooling effect of the water. Therefore these flow meters must be installed after the air dryer and will be affected if the dryer is not functioning properly. This downside is offset by the fact that these flow meters present no pressure differential to the flow of air and recent advances in meter design has lowered the cost of some units to very low levels making them affordable even for small systems.

Compressed Air Challenge's Best Practices for Compressed Air Manual discusses the application of flow meters to compressed air systems. The following is an excerpt:

> *Many of the meters require a pipe length of at least 20 times the pipe diameter upstream and 10 times the pipe diameter downstream of the meter to reduce turbulence, which induces inaccurate results. The manufacturers' requirements must be observed for accurate readings. Mass flow meters are preferred because they are pressure and temperature compensated. It is important to be aware of the differences between mass flow (scfm) and compressor capacity in acfm or icfm. Some*

STOP OPERATING BLIND — USE A FLOWMETER

of the considerations in selecting a flow meter include estimated maximum and minimum flow rates and operating pressures and temperatures. The performance is based on an accuracy of perhaps 0.5 percent at full scale and the "tum-down" or range ability of the meter. The turndown capability is important to be certain that a specified accuracy is maintained down to whatever percentage of the maximum flow is anticipated to be the minimum. It is recommended that a flow meter be installed in the piping where the compressed air is clean and dry.

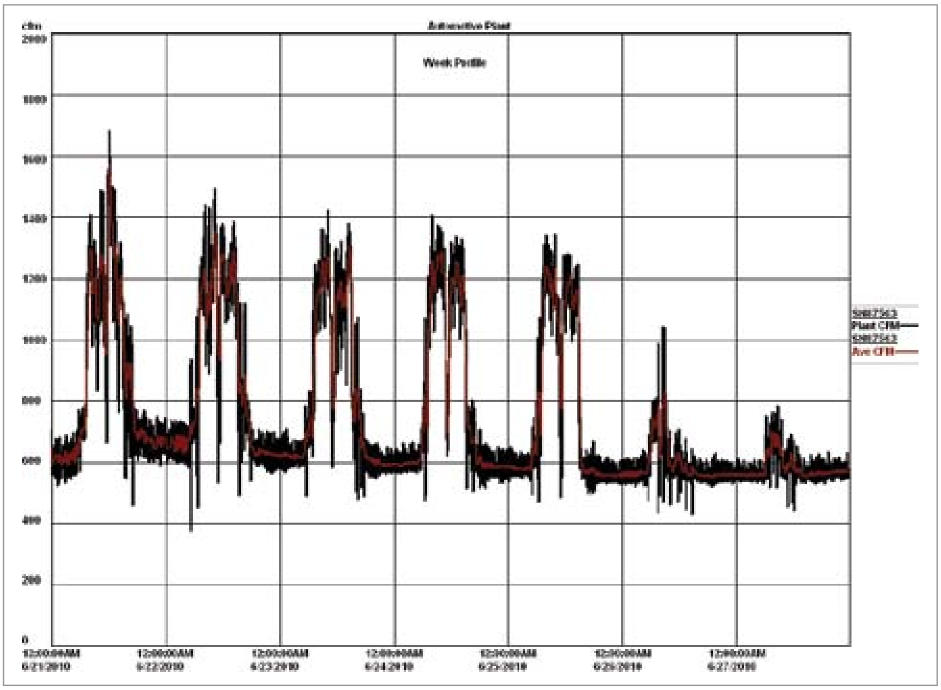

Figure 1: Week Profile (scfm).

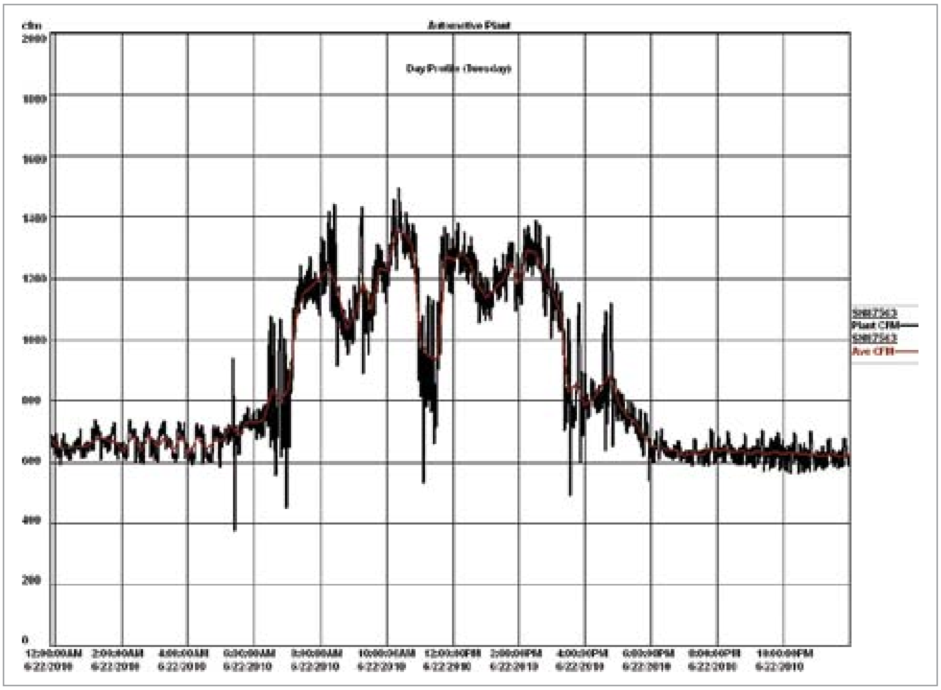

Figure 2: Day Profile (scfm).

Because a mass flow meter normally is installed downstream of dryers, the meter will be measuring a rate of flow of air from which most of the moisture has been removed. Knowing the temperature and relative humidity of ambient air to the compressor inlet and the pressure dew point of the compressed air flowing through the meter allows you to determine the difference between scfm (meter measurement) and acfm (compressor inlet flow) (see Section 1.A.6 in the BPM).

It also is necessary to know the scfm standard used by the meter manufacturer. The old standard used by CAGI of 14.7 psia, 68°F, and 36 percent relative humidity has been superseded by the new standard of 14.5 psia, 68°F, and 0 percent relative humidity. The old standard cubic foot requires 1.38 percent more acfm due to pressure and 0.83 percent less acfm due to moisture content, giving a net positive difference of only 0.54 percent.

A regenerative dryer can use up to 15 percent of the incoming compressed air supply as purge air to regenerate the desiccant. Installing flow monitoring sensors upstream and downstream of the *dryer could be expensive but will provide the necessary monitoring to ensure the dryer is not purging more than is required.*

The installation of a compressed air flow meter in the main supply header will provide an accurate usage profile and also the plant leakage rate during non-production periods. In addition, when combined with electrical consumption readings, the ratio of output air flow to input power provides the basis for measuring system efficiency.

Flow meters in the system are measuring plant demand and not compressor full load outputs. However, if it is noted that system pressure is stable or falling when compressors are fully loaded, the flow meter reading is the entire output of the compressors that are running. Correct interpretation of the recorded results is very important before reaching conclusions. Permanent flow meters are not usually found in systems below 1,500 scfm.

In some cases, permanent insertion measuring ports can be retained and one portable meter can be utilized throughout the system to monitor air usage in particular departments. Measuring flow during non-production hours can provide information on leakage rates or inappropriate uses of compressed air. It is difficult, but often very effective, to charge departments or processes for the use of compressed air.

Use of the Flow Data — Real Example

Figure 1 and 2 shows an example of an output of a flow meter in measuring the flow profile of a large automotive product manufacturing plant that operates in a one shift 5 day a week operation.

On inspection of the profiles we can see from the data that the plant flow characteristic is typical of a shift oriented facility. Main work activity starts at about 7:00 am and finishes about 3:00 pm with rest and lunch breaks evident throughout the day. As is normal, the period just before lunch is the most active part of the day. It appears the highest activity is on Monday, with workload decreasing steadily as the week wears on. The average flow for the plant is about 750 cfm.

An interesting characteristic of the data is the compressed air flow in the times between production shifts. It appears that during off hours on weekdays the plant flow ranges between 580 and 700 cfm. During weekends the flow, presumably due to leakage and production machinery left on, is about 560 cfm. Amazingly, this wasted flow, measured during times where there is no production, amounts to 75% of all the compressed air produced.

When plant staff became aware of this situation they were interested in knowing what exactly was causing this wasted air flow. Because they had a flow meter they had a ready tool for measurement which they could use to do an assessment on a non-production day. Using an ultrasonic leak detector staff performed a scan of all areas of production to find areas of use. Whenever a significant item was found it was isolated from the system and the corresponding time was recorded. Once the exercise was completed a final flow total was tallied by observing the flow meter and the various items isolated by noting the flow reduction on the available data log chart associated with the time the load was shut off. In this particular case leaks were not the total cause of the off-hours flow, amounting to slightly more than half the total flow:

TABLE 1: CONSTITUENTS OF DEMAND — OFF HOURS

ITEM	FLOW (SCFM)	% OF TOTAL
Paint Agitators	60	11
Laser Desiccant Dryers	100	18
Breathing Air Purifiers	113	20
Leaks	287	51
Total	560	

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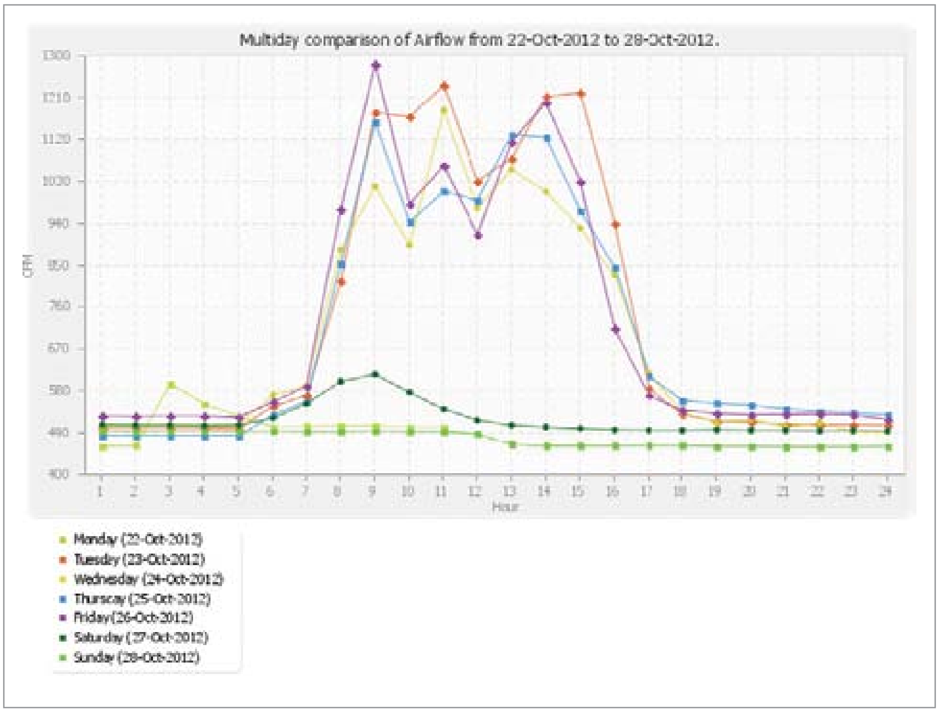

Figure 3: Multi-Day Airflow Comparison (Courtesy Air Power Analytics).

Daily average CFM consumption based on 7 day total.

% of Max. CFM	Hours	Average CFM	Avg. kW	Specific Power	Daily kWh	Daily Cost	Annual kWh	Annual Cost
80	0.1	1,490.39	303.73	20.38	30.37	$1.64	10,631	$574
75	0.1	1,396.02	296.04	21.21	29.60	$1.60	10,361	$560
70	0.4	1,303.69	280.36	21.51	112.14	$6.06	39,250	$2,120
65	0.6	1,204.22	258.63	21.48	155.18	$8.38	54,312	$2,933
60	0.8	1,114.90	245.12	21.99	196.09	$10.59	68,632	$3,706
55	1.1	1,025.87	233.29	22.74	256.62	$13.86	89,817	$4,850
50	0.9	937.71	220.67	23.53	198.61	$10.72	69,512	$3,754
45	0.7	843.16	196.99	23.36	137.89	$7.45	48,262	$2,606
40	0.3	745.51	170.70	22.90	51.21	$2.77	17,924	$968
35	0.9	643.98	142.12	22.07	127.90	$6.91	44,766	$2,417
30	7.5	541.93	117.41	21.67	880.57	$47.55	308,199	$16,643
25	10.6	486.89	102.04	20.96	1,081.64	$58.41	378,572	$20,443
10	0.1	209.95	110.67	52.71	11.07	$0.60	3,873	$209
Totals	**24**	**625.53**	**135.73**	**21.70**	**3,268.89**	**$176.54**	**1,144,111**	**$61,782**

Figure 4: Daily Airflow Comparison (Courtesy Air Power Analytics).

Armed with this new knowledge the plant personnel set out to find solutions to the issue of after-hours flow. These reductions have been added to a system upgrade project where the load reduction savings will in part help pay for a new Variable Speed Drive compressor and cycling dryer. The flow meter has been reused and has been placed in service as part of an innovative permanent air system monitoring system that generates weekly efficiency reports that track savings due to leakage reduction and changes to compressor control modes. Example outputs of this system are shown in Figure 3 and 4.

Because this customer is constantly measuring the flow, and analyzing the data weekly, the savings for the project can now be verified by the power utility and the leakage levels tracked. Before the installation this customer was operating blind and had no idea of the level of waste in their system. Use of a flow meter has opened their eyes to new potential and the resulting improvements have saved significant operating costs. BP

To read similar ***Measurement Technology*** articles, visit www.airbestpractices.com/technology/instrumentation

"Before the installation this customer was operating blind and had no idea of the level of waste in their system. Use of a flow meter has opened their eyes to new potential and the resulting improvements have saved significant operating costs."

— Ron Marshall

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TECHNOLOGY PICKS

Sullair Now Offers V250S Single Stage Compressor with VSD Technology

Sullair Corporation is pleased to announce its expanded line of V250S Single-Stage Rotary Screw Air Compressors with Variable Speed Drive technology. Designed to combine the simplicity of Sullair's basic single-stage rotary screw air end with today's most innovative energy saving technology, these versatile compressors offer a choice of three Variable Speed Drive models ranging from 250 to 350 hp, with capacities of 1085 to 1580 cfm, and pressures of 100 to 125 psig. All three models are available with Sullair's exclusive WS Microprocessor Control System.

With today's energy costs representing nearly 82% of the total operating expense of a compressed air system, Sullair continues to utilize the latest technology and develop systems that will help balance these escalating costs. Among the many new alternatives is Sullair's Variable Speed Drive system which is designed to match compressor speed with air demand for maximum operating efficiency and lower energy costs. By adapting speed to output, the Sullair V250S single stage compressor with Variable Speed Drive keeps the system operating at maximum efficiency. This is one of the most effective ways to conserve electrical power, while reducing stress on electrical and mechanical components for longer equipment life.

Designed to optimize energy savings, extend service life and minimize maintenance, the Sullair V250S VSD Single Stage Compressor features the same footprint and operating characteristics as comparable Sullair constant speed models. Additionally, the new V250S Variable Speed Drive models offer enhanced performance with the addition of Sullair's WS Microprocessor Controller. Developed for reliability, simplicity and comprehensive protection, this system features an easy-to-read graphics display to highlight frequently used compressor information. This controller is also programmed to monitor all necessary functions, including protection from abnormalities. It also provides a WSPC interface for service diagnostics and trending capabilities.

Visit www.sullair.com

New EnergAir Retrofit Compressor Controller

The NEW Metacentre™ Q1 Retrofit Compressor Controller provides a cost effective 'off-the-shelf' solution for replacing damaged or obsolete compressor controllers or to upgrade older electro-mechanical compressor controls.

Flexible hardware, user configurable Inputs/Outputs and pre-programmed application software make this advanced compressor controller compatible with almost any positive displacement type air compressor. Q1 features a backlit 240 x 160 graphic display and membrane switch keypad for easy and intuitive access and interrogation of software menus.

Inputs/Outputs include 8 digital inputs, 8 relay outputs, 2 x 4-20mA analog pressure inputs, 1 x user configurable KTY/PT100/PT1000 analog temperature input and 1 x 4-20mA analog output (for VFD speed control). Communication features include AIRBUS485™, our advanced master control protocol for connecting with Metacentre™ master

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control products. MODBUS RTU slave device capability is also provided as standard and PROFIBUS DP or DEVICENET capability is available via option module.

Regulatory approvals include UL, CSA & CE.

Visit http://www.metacentre.eu/products/airmaster-q1-retrofit-std-rotary-compressor-controller or e-mail: sales@energair.com

New BOGE Compressor Station Controller

The airtelligence provis 2.0 controls complex compressor stations of up to 16 rigid or frequency-controlled compressors of various makes in an intelligent and consumption-independent way. The control visualizes central parameters (system pressure, volume flow rate, compressor status and operating times, etc.) on the web server in a clear manner. In addition, up to 24 accessory components, such as refrigerated air dryers, filters, fans, dampers or sensors can be integrated. Based on the actual compressed air consumption, the airtelligence provis 2.0 determines the increased or reduced demand and automatically selects the ideal compressor combination. As a result, users ensure consumer-oriented, energy-efficient and in particular cost-oriented operation of their compressed air systems.

The PLC control with an intelligent control algorithm makes a pressure forecast based on the actual consumption data and also includes the reaction times of the connected compressors. This ensures that the compressors are always activated at the optimum point of time and that the specifically required compressed air rate is provided at a minimum energy input. The airtelligence provis 2.0 optimizes load and no-load times by reducing or avoiding frequent cycle behaviour. In addition to an optimization of the delivery quantity, the customers can also select an operating hour or maintenance hour optimized mode for the compressor station.

Despite its sophisticated functions, the airtelligence provis 2.0 is easy to program and parametrize. On a high-quality 9-inch TFT colour display (800 x 480 pixels) with LED black light, parameter assignment of the control is made intuitively on the touchscreen. The touchscreen visualizes, for example, data about the current operating status, progression charts for volume flow rate and pressure profile, the current CO_2 emissions, trend displays with historical data as well as the pressure dew point. An integrated USB connection enables the loading of software updates or a subsequent parameter assignment.

Visit www.boge.com/us or email: s.woodward@boge.com

FIPA Introduces Air-Saving Ejectors

FIPA ejectors save energy without compromising cycle times. Thanks to the integrated pressure regulation of this new product, consumption of compressed air and energy can be significantly reduced. "Our new ejectors are another example of how FIPA meets current market needs thanks to a sophisticated solution design," said Rainer Mehrer, President and owner of FIPA.

When thinking about ways to reduce energy costs, electricity and heat immediately come to mind. The element of compressed air however, has considerable savings potential as well. FIPA's EKPP, EKP, and EMM Series Ejectors can make a substantial impact here. Equipped with automatic pressure regulation, they reduce compressed air usage by up to 50% per work piece, regardless of its porosity. In addition, the EMA and EKP-LSE Series Ejectors can achieve savings of up to 97%, for airtight work pieces, thanks to the electronic air-saving function.

Industrial compressed air systems typically operate at around 58 to 116 psi. All FIPA ejectors use 50.8 psi internally, reaching the maximum vacuum level at a feed pressure of 58 psi. To save energy, higher feed pressure is automatically reduced to 58 psi internally.

TECHNOLOGY PICKS

Because of that the ejector never uses more than 50.8 psi regardless of the actual feed pressure. Although comparable solutions using multi-chamber ejectors reduce air consumption as well, they suffer from a system-induced higher evacuation time. In other words, it takes longer for the vacuum to build up — resulting in increased cycle times and decreased efficiencies.

Visit www.FIPA.com or email therndon@fipa.com

New Ashcroft DG25 Digital Pressure Gauge

The new Ashcroft DG25 digital pressure gauge provides a 5 full digit LCD in ranges up to 25,000 psi. Available in accuracies of 0.5% and

0.25% FS, this new design boasts a minimum battery life of 2000 hours. Standard features include an IP67 enclosure, selectable units of measure, a 20 segment bar graph indicator, min-max, tare and a list of agency certifications. A backlight and rubber protective boot are also available.

Visit www.ashcroft.com or tel: 1-800-328-8258

New Material for Hot Surfaces Available for piGRIP® Suction Cups

Piab, a leading supplier of industrial vacuum technology, introduces a new material for its line of piGRIP® suction cups as well as its smaller Bellows and Universal models.

The material — HNBR is known for superior mechanical properties that equates to excellent durability, tear and abrasion resistance. This material provides an extended lifetime compared to conventional suction cup materials.

A key application for this new suction cup material is injection molding. The process to pick a part out of a mold can now start earlier without waiting to cool down the tool or part. The material provides an advantage of shorter cycle times and in many cases less energy is needed for the cooling down process. The quicker the robot picks parts from the mold, the more parts can be produced. Other applications include handling windshields, wall and floor tiles, pottery, porcelain and other molding and casting operations with a high degree of automation.

The suction cups are Silicone-free (PWIS free) meaning it can be used to handle parts prior to the painting process. Leaving no mark behind, they are also suitable to use on sensitive surfaces, such as glass.

The unique modular piGRIP® suction cup platform offers this cup material in four sizes from 29-79 mm. That plus an endless amount of fittings and bellows combinations makes it easy to find the right cup for your application. To make a complete program for handling smaller parts, this material is also available for the smaller Bellows and Universal models in sizes from 10-20 mm.

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Sustainable Energy Savings with Compressed Air Best Practices®

Compressed Air Best Practices® is a technical magazine dedicated to discovering **Energy Savings** in compressed air systems. Each edition outlines **Best Practice System Assessments** for industrial compressed air users — particularly those **managing energy costs in multi-factory companies.**

"Retrofitting the 8 case packing machines with 3-position valves reduced our idle cfm from 80 to 15 cfm – on each case packer. With the right air compressor controls allowing the electric motors to turn down, the annual energy savings from one case packer paid for the whole project."

– Gregory Rhames, Asset Reliability Manager/Site Energy Manager, Verallia Glass, Jan/Feb 2012 Edition of Compressed Air Best Practices®

"Demand Side" and "Supply Side" information on compressed air technologies and system assessments is delivered to readers to help them save energy. For this reason, we feature Best Practice articles on when/how to correctly apply **air compressor, air treatment, measurement and control, pneumatic, blower and vacuum technology.**

Industrial energy managers, utility incentive program managers, and technology/system assessment providers are the three stakeholders in creating energy efficiency projects. Representatives of these readership groups guide our editorial content. The Compressed Air Best Practices® Editorial Advisory Board guides our mission to help create more energy saving projects.

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