Greener Compressed Air Systems

Andy Edwards, Ash Grove Cement, USA, and Paul Edwards and Daryl Beatty, Compressed Air Consultants, USA, outline the benefits of green initiatives on compressed air systems.

Introduction

If green is defined as conserving natural resources while reducing the environmental impact, then the following areas offer the greatest opportunity for "greening" the compressed air system:

- Conserving natural resources:
  - Reducing energy consumption.
  - Reducing lubricant replacement and consumption.
- Minimising environmental impact:
  - Reducing waste oil handling and disposal.
  - Improving dust collector performance.
  - Controlling condensate effectively.
  - Utilising waste heat.

While there are other areas of improvement, such as noise reduction and maximising machine life, the overall impact is minimal compared to the above. With that in mind, the ultimate purpose of any green improvement project for a compressed air system is to transform it into a more repeatable process that supports the needs of production at all points in the plant at all times at minimum cost, while having the smallest environmental footprint.

Just as important, greening the compressed air system makes good business sense.

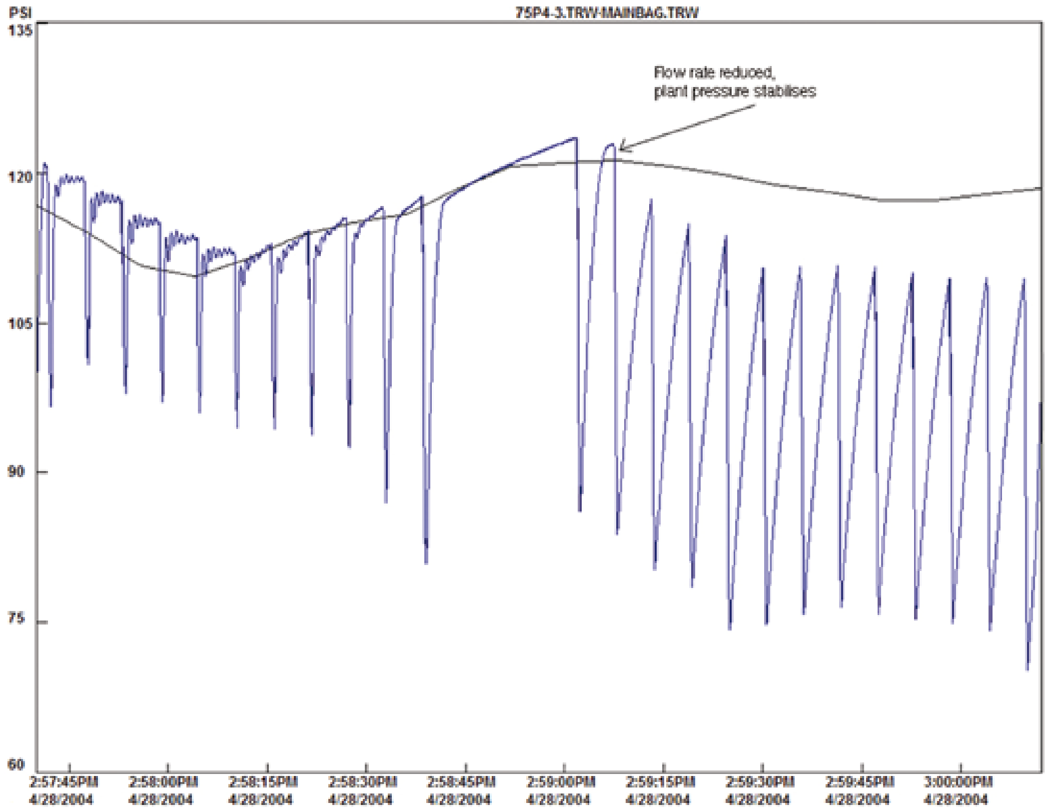

Figure 1. Refining dust collector settings stabilises plant air pressure.

Business perspective

Greening the system often brings large reductions in operating cost while improving the plant's productivity. Capturing these values requires two processes within the plant to be improved. First, the business process of how decisions are made on the air system needs to change. Second, the technical process itself has to be changed based on better data and knowledge. The first case study illustrates the problem with how systems are often run.

One terminal used to operate on a 75 hp compressor. A second 125 hp compressor was run for eight hours per week when its bagging operation came online. As time progressed, low air pressure problems on the loadout silo roof caused a dust collector to malfunction. To solve this problem, the plant tied the 125 hp machine into the 75 hp system and ran both machines for all shifts. At the same time, the compressed air's moisture content increased dramatically.

The maintenance department asked the local compressor company to help solve the moisture and pressure problem. The vendor evaluated the system using an automatic survey tool and recommended that a new pipe be run to the silo roof and a new compressor be installed for an estimated cost of US$35 000 - 50 000.

When a study of the system was carried out by an outside expert (not in the equipment business), a very different problem and solution emerged. The consultant found that the dust collectors on the roof were set up aggressively and were consuming far more air than was necessary to keep the bags clean. It was believed that the aggressive schedule was chosen to keep water off the bags. Further analysis showed that the moisture problem was a combination of issues, but it was most attributable to an incorrect tie-in between the two systems. The tie-in was upstream of the dryer on the 125 hp system, which meant that any time it was on, wet air was being fed to the plant.

It was determined that the solution to the problem had nothing to do with new pipe or new equipment: the existing system needed to be run more intelligently. The first step was to supply the air from the dry side of the dryer, which required less than 15 ft. of pipe. The plant's operators could then reset the dust collector controls and slow the recovery rate, which would in turn reduce the overall impact on the system. Figure 1 shows that simply adjusting the recovery rate for the dust collector stabilised plant air pressure at a higher average level.

These actions, combined with adjusting the pulse duration and interval, decreased the demand sufficienctly so that the plant could run on the 75 hp compressor for all shifts but one. Since the system was more stable, the operator ran the plant at a lower pressure, reducing energy consumption. With a small investment for the cost of the study and US$500 of pipe, the annual operating cost was reduced by US$35 000.

These results are typical of what happens in many plants. A fundamental financial problem with compressed air systems is that improvements are often made through discretionary spending. The lack of funding for the study forces engineering and maintenance to rely on compressor companies who have a vested interest in using equipment to solve a plant's problems.

Deciding to improve the air system as an ROI project is the first step; however, there are several other critical steps:

- Ensure that production personnel are part of the improvement team. Since they are the users, they drive the system and without their cooperation, improvements are limited. In North America, compressed air costs US$100 - 250 per scfm pa. When it is understood that an air lance is left on in a gypsum bin that exceeds US$10 000 annual operational costs, solving the root cause becomes a priority. One plant spent over US$100 000 pa on air lances to feed their finish mills. Once the true cost was understood, changes were made.
- Ensure that the entire system is analysed by someone who understands the process. Use an independent company wherever possible to perform the analysis.
- Provide feedback on system operation and cost to production and engineering/ maintenance so that the system can be trended and the savings retained.
- Baseline all plants from a corporate perspective.
- Educate operators and engineers on the cost and operation of their system.

Benchmarking

While the first five steps are fairly obvious, benchmarking experience gained at Ash Grove Cement Company can provide significant value to other cement companies. Ash Grove uses benchmarking as a tool for identifying opportunities. Following audits of the company's nine cement plants and one import terminal, it was obvious that there is not a "one size fits all" solution to compressed air and that each plant presents its own challenges. Benchmarking is used extensively in the cement industry for kilns and mills to compare production, fuel consumption, power consumption and other processes, so it was decided to apply it to compressed air systems. In other manufacturing industries, it has been suggested that compressed air costs can range between 10 - 30% of a manufacturing plant's power bill, and it can become an easy target for cutting overall plant costs. However, in a cement plant, the majority of the power use is consumed in grinding operations and fans. Compressed air systems have been found to be significantly < 10% of a plant's electrical consumption. Most managers and engineers use the Pareto principle when tackling issues and look at the higher cost items, therefore, compressed air usually ends up at the bottom of the action list. However, there is also credence to the approach of scrutinising the details, and the larger items will rise to the surface. Abuse of compressed air in most cases hides bigger issues (bearing cooling, airslide assist, vibrators on chutes, bag filters on continuous pulse, etc.). Once the cost of band-aiding an issue with compressed air has been determined, identifying and fixing the root cause becomes much easier to justify.

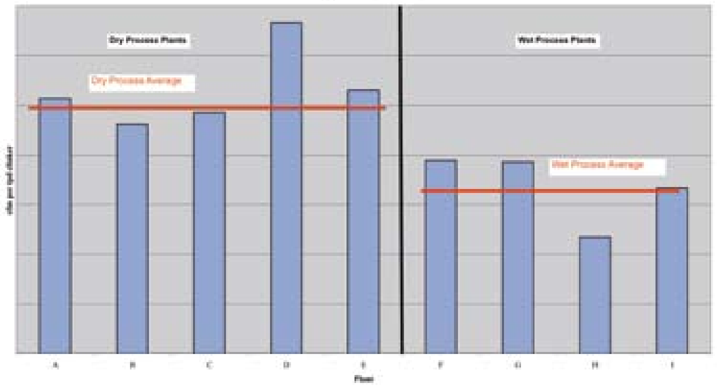

Figure 2. Plant air usage cfm per tpd nominal clinker capacity.

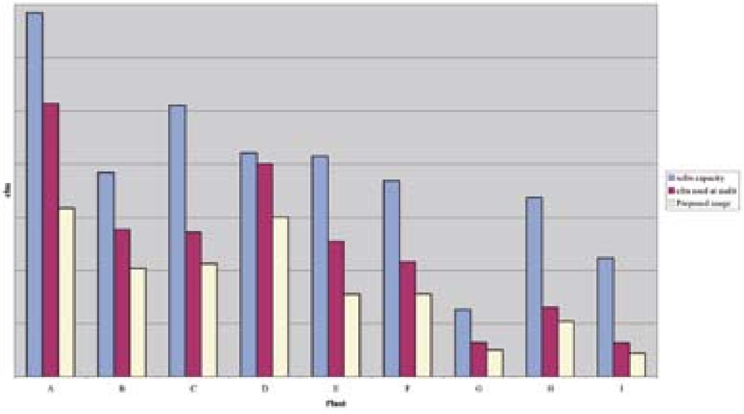

Figure 3. Plant compressed air capacity and usage.

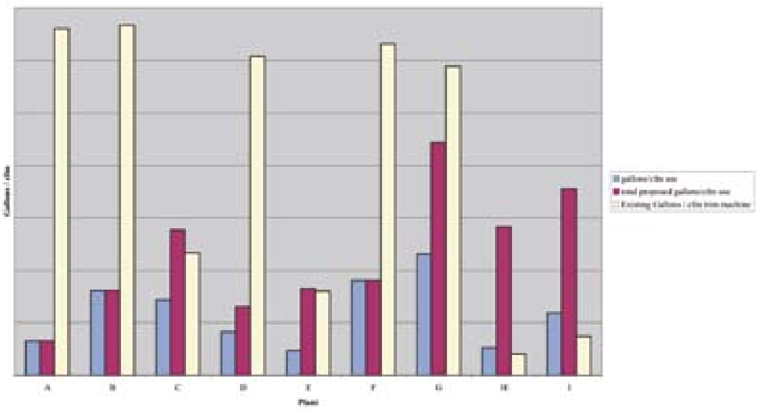

Figure 4. System capacitance benchmarking.

Figure 2 shows plant air use only, without any air atomised conditioning tower systems. Plants A to E are dry process, F to I wet process, and it can be clearly seen that the wet process plants use less compressed air than the dry process. For this set of plants, on average, the specific air consumption of the wet plants is approximately 35% less than that for dry plants, and the best wet process plant uses about 50% of the specific air consumption of the best dry plant. The big drivers in air use on a dry plant vs wet plant are the number of pulse jet bag filters and the number of air cannons involved in a dry plant.

Figure 2 shows that there are opportunities to be realised at plant D, but on further analysis, significant savings could be achieved at even the most efficient plants. Looking at the installed capacity vs usage at audit and potential usage (Figure 3), in all cases, no additional capacity on the main plant air systems was needed.

The differences between installed capacity and usage depends on the size and number of machines at each plant, e.g. plant A has nine machines installed, whereas plant H uses one machine with a machine of identical size for back-up.

In addition to the overall benchmarking, by looking at secondary measures such as system capacitance (Figure 4), system pressures, efficiency of supply (cfm/HP) etc., specific areas of opportunity for each plant could be identified, costs estimated and the decision making process on action items could be made in a more informed manner.

Reducing energy consumption

The potential energy reduction for the compressed air system in cement plants is typically 15 - 35%. That is usually US$150 000 - 200 000 per 1 million tpa at US$0.055 per kW/h. That equates to roughly 3 million kW/h at the lower end of the spectrum.

Every plant uses and abuses compressed air in its own unique way. Knowing this, and understanding the real cost of air, makes a strong case for examining the entire system including supply, distribution and demand.

To understand and quantify the opportunity, a plant needs a compressed air audit.

While energy is the primary financial tool to justify the audit, other incentives exist, including reducing repairs and maintenance of compressors and dryers, as well as downstream equipment such as dust collectors, which can be sensitive to moisture, dirt or oil. In some plants, productivity is impacted negatively by air pressure and quality. In one plant, wet air created havoc in a finish mill baghouse, resulting in an extra 4% downtime. In another plant, wide swings in plant air pressure caused a finish mill FK pump to shut down approximately once every month.

Another reason to consider a study is to avoid purchasing new compressors. In 45 plants studied to date, none required new compressors for capacity reasons. In a few cases, new compressors made economic sense due to the current unit's failure or the ability to meet the load more flexibly; but in most cases, cement plants have over 20% extra capacity.

At Ash Grove, the set of audits identified a collective opportunity to reduce operating costs in excess of US$800 000. While productivity gains, due to improvements in both air quality and quality of supply, are more difficult to quantify, improvements in these areas lead to smoother operation of the plant and better use of resources. For example, one plant commonly had issues with frozen air lines in the winter, forcing operators to locate frozen lines and heat them up; fixing the air quality has all but eliminated the problem. In another plant, sporadic low air pressure on a burner platform was eliminated, which caused issues with kiln thermal cameras. In a third plant, installating storage with metered recovery has eliminated the use of a portable diesel compressor. Simple education about the cost of compressed air leads to changes in thought and behaviour.

What should an audit cover?

There is no universal definition of an audit; however, the following approach offers the greatest level of improvement and financial gain.

Typically, the audit should cover demand, distribution and supply. One to two thirds of the cost reductions are attributable to changes in demand. For instance, as described earlier, compressed air in the United States costs US$100 - 250 per scfm pa. As long as the compressor system's controls respond intelligently, every scfm removed from demand results in that amount flowing to the bottom line. Generating a 20 scfm improvement by finding a dust collector pulse jet duration set too high would save US$2000 - 5000 pa at no cost.

Demand side evaluation

On the demand side, each application should be catalogued to understand its operation. In the case of a dust collector for instance, type of control, duration and the interval between pulses should be determined. Additional testing by measuring the volume used in each pulse is recommended.

For example, if a pulse jet is set for 300 milliseconds and pulses every 10 seconds, the auditor measures a demand of 20 scfm. The auditor then knows that at least 10 scfm can be removed by setting the pulse duration to 150 milliseconds or less. The auditor then repeats this process on an application-by-application basis throughout the plant, which ultimately creates a new demand profile. In some plants, fixing the dust collectors alone would have saved 400 scfm and in most cases required minor amounts of capital.

A second example of the value of demand side analysis was the opportunity found on a 300M FK pump. A flow test of the seal air showed that the demand was 80 scfm higher than suggested by FLSmidth's manufacturer's manual, costing the plant US$9800 pa more than necessary. The root cause of the excessive demand was a worn or missing orifice and excessive pressure. In some plants, audits have found seal air pressure over 100 psig, which can ultimately cause shaft problems that lead to unnecessary repair and downtime.

A third example (Figure 6) involved a kiln camera that was running hot. An air lance had been set up to keep the housing cool - the pipe entering from the right side of the picture. Further examination of this showed that the enclosure cooler pressure setting was 30 psig, which, according to the manufacturer, did little cooling. The pressure to the cooler was increased and the camera no longer needs the air lance, resulting in savings of US$15 000 pa.

Figure 5. Another FK pump example where an off pump consumed air since the solenoid was bypassed.

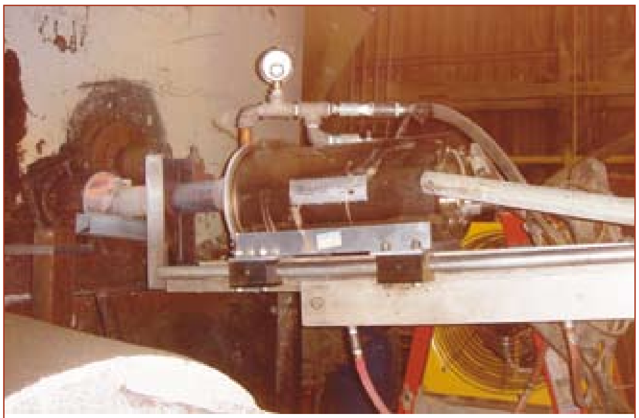

Figure 6. An air lance cooling the kiln camera.

Figure 7. A tie-in between the low-pressure and high-pressure systems.

No discussion regarding energy is complete without discussing open blowing. Compressed air's flexibility to keep product moving, as well as its immediate availability, often make it the operators' choice to keep production running. There is a cost associated with it and until that cost is known precisely, there is little incentive to modify its use. In Figure 7, the plant had problems with an air slide and the operator connected a 3 in. valve to the air slide blower system and cracked it open. The actual demand for this application varied from a measured 330 scfm when the vertical roller mill (VRM) was running, to an estimated 630 scfm when the VRM was down. The root cause of insufficient pressure in the air slide when it was run off the blower and its actual application (40 m). Since the blower was ten times more efficient than the compressor, the recommendation was to relocate the blower and eliminate the use of compressed air.

Leaks are an important aspect of compressed air improvement projects and a good study documents the leaks without focusing on them. Leaks are actually a smaller percentage of the total load than is commonly thought. Even in the noisy environment of a cement plant, the leaks worth fixing are almost always audible without ultrasonic detection. The real value in ultrasonic detection is in increasing the speed at which leaks can be located and tagged.

Distribution analysis

It is also important to understand the distribution system and how air is delivered to the applications. The primary issue in distribution is the pressure drop, and understanding the differential pressure between the compressor room(s) and the end points is critical to producing accurate and repeatable results in those applications.

Distribution analysis is carried out by concurrent pressure logging in the compressor rooms and in various extremities in the plant. In general, the differential should be between 1 and 5 psig throughout the facility. In some cases, extremities such as the crusher may have applications that require lower pressures than applications closer to the compressor room. In those cases, fixing a high pressure drop may not make economic sense.

However, if pressure is kept excessively high in the compressor room to support some particular application, then it pays to evaluate the cost of fixing the pressure drop vs the electrical cost associated with the higher pressure. The cost associated with high pressure is twofold. First, there is artificial demand, which is nothing more than the excess compressed air consumed at applications that are poorly regulated or unregulated. To those applications, when pressure is increased, the consumption rises. The second cost associated with excess pressure is the extra electrical power generated in the motor to increase the pressure.

Increasing the pipe size and adding storage are solutions, but they are not the only solutions. First, demand side improvements could reduce the demand to a particular section of the plant. When the demand reduction is significant enough, there is an increase in pressure to that area of the plant, since the source pipe is carrying less flow. In the case history at the terminal in the beginning of the article, resetting the dust collectors saved 150 scfm and increased the pressure available to the dust collectors. Pressure also increased throughout the entire operation. Other solutions include dedicated compressors or boosters similar to what is often seen on clutch systems.

As is the case with demand side improvements, the important aspect is to evaluate the potential improvements financially and precisely, and avoid "rules of thumb" wherever possible. The evaluation has to consider actions being taken in supply and demand and the impact that they would have on distribution pressure.

Supply side analysis

As previously mentioned, an air system is a complex interaction that starts in demand, working its way through distribution with the compressors responding to events that have already occurred. The evaluation of this system can be compared to untangling spaghetti. In systems with a single supply the analysis is straightforward, whereas in systems where there are multiple compressor rooms, the evaluation is more complex.

From an energy perspective, demand and controls are the most important aspect of energy consumption, brand and type of compressor are a secondary consideration. The financially-savvy plant engineer pays as much attention to details when picking controls as he/she does to selecting a compressor company with which to work.

The basics of optimising compressors are fairly straightforward. The first action is to combine as many systems as possible and trim with only one compressor. The strategy is to baseload the most efficient compressors and then trim with one compressor, changing the trim compressor in response to the size of the variation from average. While centralising the compressor system is good whenever possible, there are techniques that allow a plant to leave the compressors in place and create a virtual compressor room. This has a significant positive impact on capital and eliminates the pressure drop risk associated with changing the flow pattern of air in a plant.

Controlling the existing machines, combined with demand side improvements, has a far better payback than a new machine. In most plants, 20 - 30% of the compressors can be turned off while improving the air quality and pressure stability in the plant. Turning these units off has the added benefit that when a major failure takes place, the plant has the option to use one of these "off" machines permanently or temporarily without adding cost. So this approach provides both financial and environmental benefits, since the equipment will last longer.

Every system is different and should be evaluated as such. Evaluation typically includes understanding the potential savings between two-stage and single stage compressors; the use of reciprocating compressors, including small unitary types in remote areas, such as the maintenance building and crusher areas; and compressor type, such as oil-free vs oil-flooded screw compressors with clean-up. There is no one perfect compressor for every plant. In some plants, multistage centrifugal compressors may make financial sense due to system size, availability of clean air and clean water. In some cases, oil-free screw compressors with the heat of compression dryers may make sense. In other plants, two-stage flooded screws can be the best long-term investment depending on conditions; and systems that have two-stage, double-action, water-cooled reciprocating compressors are the most efficient.

Part of the overall efficiency issue relates to the drying requirements for the system. The air should be cleaned to the minimum amount required to do the job effectively. Many plants use only after-cooling on the air fed to the spray tower or cooler spray systems. Plants in warmer environments can often live with refrigerated drying only, while plants in colder climates require desiccant dryers.

Within each type of dryer there are variations that can have a material impact on the actual energy cost of the dryer, and in one case, impacts upon the compressor selection. In the case of refrigerated dryers, the primary control modes include non-cycling, cycling and variable speed drive. In the desiccant world there are heatless, heat-reactivated, blower purge, heat of compression and vacuum purge.

One technique worth investigating is dryer blending. This technique is valuable for plants located in areas where there are some freezing conditions, but which have significant periods throughout the year above 50 °F. In dryer blending, air flow to a refrigerated air dryer and a desiccant air dryer is controlled so that the combined flow results in a dewpoint 20 °F below the existing ambient conditions. On warmer days all the air would go through the refrigerated dryer, taking advantage of this dryer's lower energy consumption. As the weather becomes colder, a greater portion of the air would flow through the desiccant dryer, taking advantage of this dryer's ability to drop the dewpoint below the freezing point. As long as the desiccant dryer has energy-saving controls installed, the minimum required dewpoint can be achieved using minimum energy.

Minimal energy can be obtained by using a compression type dryer. This dryer uses the hot air exiting the compressor to provide the heat that strips the moisture from one of the two desiccant beds. The air then enters a cooler that condenses the moisture that just stripped off the bed, as well as some of the moisture from the original air stream. The air then enters the final bed where it captures the moisture still present in the air stream on the second bed. The downside to this technology is that it requires oil-free compressors. With this option, evaluation should consider the total energy cost from intake to compressor room discharge and not isolate the dryer or compressors by themselves.

Filtration should be chosen with pressure drop in mind. One technology that is particularly well suited to cement operations involves mist eliminator type filters. Mist eliminators are usually depth of bed type filters and have a low pressure drop (1 - 2 psig) and a 5 - 10 year element life. Other filtration can also achieve clean air with a low pressure drop so the technology is not nearly as important as the end user.

For drains, normally wet applications such as aftercooler separators, prefilters, wet tanks and refrigerated air dryers should use 'no loss' type drains. 'No loss' drains waste no air and do not require adjustment as the weather conditions change according to the time of day or year.

From a cost perspective, normally dry locations can use 'no loss' drains or solenoid type drains with short cycles and long intervals. A 0.25 in. solenoid drain will consume 50 - 100 scfm when employed. If a 100 scfm solenoid drain operates for two seconds every ten minutes, the average demand is 0.33 scfm, which would cost US$33 - 100 per annum. The economic decision is then based on the installation cost of the two drains compared to the cost of the wasted air.

Using waste heat

Compressors convert all of their energy into waste heat including radiation, convection and conduction. The majority of the waste heat is discharged into the atmosphere in the case of an air-cooled machine and into the cooling water in the case of a water-cooled machine. In cement plants, there is so little use for waste heat that heat recovery has limited value. The one area that does have value is for space heating in the compressor room when air-cooled machines are used. Thermostatically-controlled louvers divert air that would normally be blown into the atmosphere into the compressor room to maintain the temperature of that room. In Figure 8, the heat recovery unit is the green box on top of the green compressors.

Improving dust collector performance

Variations in compressed air pressure and air quality can negatively impact upon a dust collector's ability to clean. Solving low air pressure problems at a particular dust collector rarely requires significant investments. More often than not, low air pressure at a dust collector is caused by a blown pulse jet or a competing application on the same line. On a rare occasion, the solution is to make changes in the distribution piping or to add additional storage.

Poor air quality can lead to releases through blinding of the bags. In freezing conditions, it is possible for ice to form in the air lines blocking air from getting to the manifold. When this happens, the pulse jets can be starved for air, preventing the bags from cleaning. There are dozens of potential root causes for contaminated air, but the principle to solve the problem remains the same: make sure the clean-up equipment is designed and working properly. Root cause analysis in the compressor room is required.

Reducing lubricant consumption and handling condensate

The majority of compressors used in the cement industry are oil-flooded screw compressors. In these units, lubricant is injected or flooded into the air end to absorb the heat of compression, seal the rotors and lubricate the bearings. This lubricant typically enters the environment either as part of the condensate or as used fluid after a change out. The plant has several options for dealing with the lubricant. The first is to eliminate the majority of the lubricant through the choice of oil-free compressors. The second is to reduce the volume of lubricant used; the third option is to ensure that any lubricant that escapes in the condensate is dealt with in a benign manner.

Figure 8. Heat recovery for a compressor room.

Oil-free compressors

There are two primary types of oil-free compressors for general plant service: rotary screw and centrifugal. In an oil-free dry screw compressor, the rotors are usually coated with a dry lubricant and are built with tight tolerances. They run at higher speeds than lubricated rotary screw compressors. Centrifugal compressors are multi-staged fans with semi-closed impellers. These units run at higher speeds with larger clearances.

These units have a low profile when it comes to lubricant as the majority of machines in the market have gearbox lubricant only requiring a single changeout each year. It should be noted that there is now a centrifugal version on the market that uses magnetic bearings and eliminates the need for lubricant altogether.

Eliminating oil from the compression process has secondary benefits when it comes to power consumption. Firstly, eliminating oil can impact the pressure drop on the clean-up equipment, resulting in the compressors running at a slightly lower hp. Secondly, the eliminating oil permits the use of heat from compression dryer technology which, as previously noted, requires no energy cost whatsoever.

There are economic costs to these technologies. The equipment has a higher initial cost that can be offset by the reduction in some of the maintenance and repair. One should beware though when determining which direction is the least expensive in the long run; there are claims within the industry that stretch the truth with regard to the true cost of both oil-free and lubricated technologies. The best way to compare the costs is to get quotes on both technologies from multiple vendors and require pricing on a five-year maintenance and repair contract. At the price that compressor companies are charging for extended warranties, it may not make sense to purchase them. However, it does force the OEM to deal with the associated risk and provide what they believe to be the real cost of their technology.

From a technical perspective, both dry screw and centrifugal compressors are less forgiving when it comes to operation in hot or dirty environments; and while all compressors should be kept in an area as clean as possible, machine efficiencies in oil-free technologies will drop faster in environments where dust gets through the inlet filtration and chips away at the rotor coating or the impeller edges.

Each technology also has capacity-related issues inherent to its design. Dry screw compressors have an additional potential efficiency loss: normal coating wear. As the machine breaks in, there is usually a small loss in efficiency as the dry lubricants seat against each other; over time, this will increase. While the evidence is anecdotal, it would appear that the loss of flow is 3 - 5% and can be higher. Centrifugal technology is also sensitive to changes in inlet conditions due to high heat or altitude, so applying this technology properly requires more care upfront. Those interested in this technology should thoroughly investigate the claims of the manufacturers and seek guarantees.

Either of these technologies can function in the environment of a cement plant, but the decision as to which type of compressor technology should be used should be made as a secondary decision based on overall cost impact. Plants that choose the compressor technology justified on the input of the compressor companies often pay a substantial price for the bias.

Lubricated compressors

Lubrication changeout volume

As compressor lubricant stability and life have increased, compressor sump capacities have gradually been reduced by the manufacturers. Smaller quantities of fluid are now being used to perform at higher temperatures and for longer periods of time. The polyol ester and polyglycol lubricants, which are currently available, have virtually eliminated the most serious compressor reliability problems, related to varnish. Compressor varnish deposits are much more than a cosmetic concern. Users who have not upgraded to POE or PAG lubricants risk compressor problems or failure due to the three main effects of this varnish. Varnish plugs the fine passages of oil cooler tubes of compressors, causing them to run at even higher temperatures, which in turn leads to even more varnish. Varnish also plugs the orifices leading to the bearings, which can result in failure of the air end. If that is not enough, it also reduces the efficiency of the compressor by increasing the pressure drop through the air/oil separator. Fortunately, there is no need to suffer from varnish problems in compressors. In addition to the quality OEM fluids offered by most compressor manufacturers, several quality aftermarket POE and PAG fluids are now available.

Lube changeout interval

The benefits of extended interval lubricants go far beyond savings on lubricant costs: downtime, disposal and reliability are also impacted. Traditional mineral-compressor lubricants have a typical safe operating life of 1000 - 2000 hours in a rotary compressor. While many synthetic lubricants are rated at 8000 hours at a typical discharge temperature of 200 °F, lubricant life is generally expected to be reduced to 50% for every 20 °F increased in temperature. This is a concern about compressors operating near the kiln or the cooler.

Millions of compressor operating hours, in thousands of compressors, have shown this to be a safe number for compressors operating in a "clean" environment, while a few fluids boldly claim as much as 12 000 hours operating life. The situation is not quite as simple in an environment like a cement plant. Case studies in kaolin clay plants show that fluid life is not impacted in environments where the contaminant is an inert solid, as these are readily removed by good air and fluid filtration. Contamination can come in the form of the gases and fumes formed by burning low-grade fuels. Due to the adverse conditions seen in some installations of compressors near the kilns, coolers or on the tower, the potential for ingestion of alkaline dust can impact upon the fluid life. If it were to occur, the use of a short-life petroleum oil may be the only choice. For most users, extended life fluids are the better choice.

Ion exchange resin

A new development in fluid and compressor life is the introduction of ion exchange technology to remove the acids from compressor fluids, thereby greatly increasing compressor fluid life. One system, the 'compressor oil purifier', combines acid removal with ultra fine solids filtration, removing both of the major contributors to premature compressor air end failure.

In Figures 9 and 10, data was collected on total acidity and viscosity as a function of time. The red line represents the limit that requires replacement of the fluid. In Figure 9, the green line shows what would be expected after 8000 hours, while the blue dotted line shows the actual trend. After 21 000 hours, both graphs show that the lubricant has changed little in essence, at least tripling the life of the lubricant.

A system such as this is especially practical for cement plants, as it provides the highly-efficient particulate filtration necessary for such environments. The ion exchange component of the filter removes acids from the fluid, extending fluid life 3.5 times by continuously removing the acids that normally accumulate in the oil and are the primary condemning factor for those lubricants. While this technology is new to compressed air, combined with routine oil analysis, it allows users to employ condition-based oil changes. It is a green technology that is here to stay.

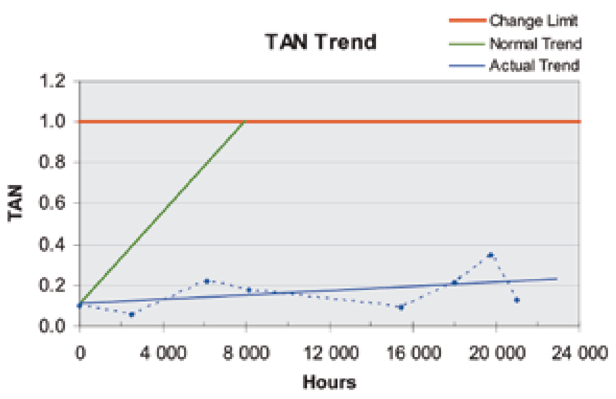

Figure 9. Graph showing total acidity number trend.

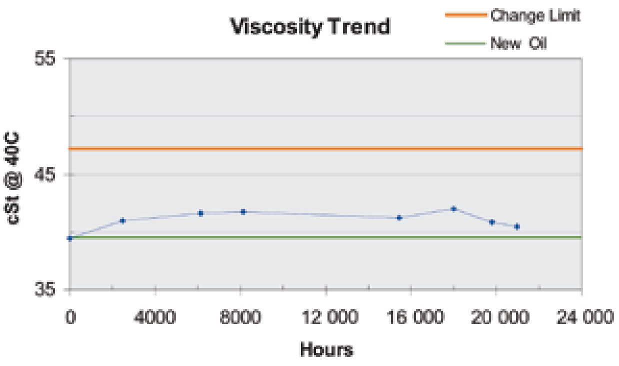

Figure 10. Graph showing viscosity trend.

Used lubricant disposal

For many cement kilns, used lubricant disposal is usually not a problem, it can be used as kiln fuel. Virtually all used compressor fluids qualify as 'waste lubricant fuels' under the EPA guidelines. For plants not equipped for capturing the fuel value of the waste fluids, disposal can be quite a concern. Waste fluid disposal can be costly and adds to the hidden costs of using short life, disposable compressor fluids. In the US, for example, there are trade industry groups such as the National Oil Recyclers Association (NORA) who provide contacts for locating established fluid recovery professionals.

Condensate separation

Compressed air cannot hold as much water as atmospheric air, so in most systems significant volumes of water are generated in the water separators, filters and refrigerated type dryers. Some oil drops out with the water in these locations and is eventually discharged. Figure 11 is from a site unrelated to Ash Grove or cement plants but shows how condensate is often handled (dumping it on the ground). The plant has choices for how to deal with condensate, including dumping it down the drain, dumping it on the ground, separating it or sending it into the kiln.

Figure 11. Condensate containing water and compressor oil draining onto the ground.

The amount of oil that comes out in the drainage is often just a few percent of the total condensate load, even though it sometimes looks far worse. In addition, the primary oil used by two of the major compressor companies are polyglycol/ester blend fluids, which are often considered biodegradable because the bacteria in soil and in many waste water treatment plants can digest these types of fluids. So the plant does have the option of contacting the local wastewater authority and sharing the data regarding biodegradability that the manufacturer should provide. However, the plant should note that some of the oils do have heavy metals, such as barium, which may make them unsuitable for disposing of down the drain and especially unsuitable for dumping on the ground.

Another option for the plant is to separate the oil from the water. There are several viable technologies to do this, but most either use gravity, membrane or activated charcoal to capture the unwanted molecules. There are also some boiling type separators on the market, however their energy cost should be evaluated as part of the decision making process. Whatever technology is chosen, it should be carried out in conjunction with the local environmental constraints and the lubricant's ability to separate; polyol esters, diesters and PAO fluids tend to separate well. Most, but not all, polyglycols separate poorly. When it comes to compressor selection and operation, environmental considerations should affect the lubricant selection.

Conclusion

Compressed air systems offer a unique opportunity to improve the environmental impact of a cement plant while improving the bottom line. Typically, cements can save 20 - 30% of the compressed air energy with a minor investment in the system that is not related to additional capacity or replacement compressors.

A secondary environmental benefit is that improvements in pressure stability and air quality can improve the performance of dust collectors and other process equipment, creating a more stable operating environment. Baselining the system and providing ongoing monitoring can help the corporation maintain these benefits and spread methodologies and techniques throughout the organisation. ●