PNEU-LOGIC

Whitepaper

Airgonomics, the New Logic for Managing Compressor Systems

BY ERIC BESSEY, P.E.

Chief Project Engineer

Pneu-Logic Corporation

Overview

Plant operators are typically unaware of the full cost of the compressed air that they use. Compressed air generation represents roughly 10% of the total energy consumed by manufacturing plants in the US. The cost of energy needed to power an industrial compressor, one that is essential to production, for just one year can be comparable to the cost of the compressor itself. If a plant's compressors aren't being used efficiently, or if there are leaks that aren't being attended to, the cost of wasted energy is significant. Using air for non-ideal applications can also contribute to high operational costs.

It's also a fact that many compressed air systems that are controlled by pressure alone are being operated at an unnecessarily high pressure in an attempt to avoid low-pressure conditions and provide the flow needed by the production process. This contributes to leaks and premature system component wear-out, also resulting in higher costs. And of course, since energy cost is directly related to the level of pressure, running a plant at a pressure that is higher than necessary also results in higher energy costs than necessary.

A solution is needed that applies positive control to all of a plant's compressors. But in doing so it's not sufficient to monitor only the pressure and productivity levels in the plant. It is also necessary to monitor the flow rate of air. Today, Pneu-Logic provides a compressor control solution that reduces costs by monitoring flow and pressure, and which works with all brands and types of compressors.

History

In the early days of using compressed air in plants, compressors were generally turned on all the time that the plant was in operation. When more air was needed, another compressor was added. The old saying was - "No one was ever fired for providing too much air." Keeping the production line running was of paramount importance, and plant managers had far less concern for the cost of operating unneeded air capacity compared to the risk in lost production due to not having enough.

About twenty years ago, people started looking seriously at the cost of compressed air and began to understand that air compressors aren't very efficient in converting electricity or other fuel sources into pneumatic pressure. They began to realize that for each dollar's worth of electricity going into producing compressed air, the factory was getting only 10 - 15% usable energy in return (compared to other power sources such as electric motors, which are typically 80-95% energy efficient).

With this realization, plant managers started to put in place simple controls that would shut off compressors when they were not needed. This control was pressure-based, with rudimentary pressure switches, and a rigid scheme of turning compressors on and off in a fixed sequence. The control system brought on compressors one at a time as the need for more flow increased, and continued to run them until a pressure setpoint for each was reached.

This scheme, which is called cascade sequencing, is prone to producing a large pressure band, i.e., the pressure in the system and the way that the air pressure responds to loads can vary significantly depending on the number of compressors that are online at any given time. Not only was that an inefficient way to operate the factory's compressed air resource, but energy can be wasted unnecessarily in the rigid sequential way that the compressor bank is controlled.

A better way is to intelligently select which compressors to use based on multiple factors. Instead of having just a rigid order of compressors that come online, a better way is to choose compressors based on the efficiency of the individual compressors, compressed air demand, production loads, and maintenance schedules.

Selecting when to run compressors and when to give them a rest can be viewed as a task that is similar to coaching a basketball team. When a compressor needs to come off line for a rest (to cool down or for maintenance related reasons), the controller will optimally replace it with a fresh one of equivalent capability. If a different game plan is called for (i.e., a different response from the compressed air system), a player (compressor) with special capabilities may be called upon. In this regard, it is critical for the control system to be able to control compressors of many different types (e.g., rotary, reciprocating, centrifugal) and capacities.

Whereas the basketball team will score more points if managed correctly, proper management and control of a factory's compressed air resources will save a company more money. A side benefit of a central, computerized control system is that it can record data and produce reports that may be used by factory executives to help plan for future capacity needs. And with the data, the cost of a factory's compressed air resource can be quantified and rolled in with other costs of production to get a complete picture of the cost of production.

How does the control system work?

An example of a controller that manages compressor resources effectively and efficiently is the PL4000 from Pneu-Logic Corp (Figure 1). This control system makes decisions based on several factors. As with the basketball team analogy discussed above, there's scoring involved. The control system considers multiple factors, including the efficiency of each compressor, its capacity, and its run time. Run time scoring enables the controller to predict when the players on the floor (i.e., compressors in operation) should be replaced by players from the bench (i.e., compressors in reserve). As the controller monitors how long a particular compressor has operated, it develops a score that changes with time and how it's been operating. Eventually a particular compressor's score will hit a threshold where the system says 'OK, you've run long enough' and rotates another compressor in its place. Based on production information, this score can be adjusted by the control system to lengthen or shorten the compressor's operating cycle.

FIGURE 1.

CONTROLLER

Pneu-Logic PL4000 Controller

When deciding which compressor to run next, the controller can't base that decision on efficiency alone, however. If that were the case, the system would tend to wear out the most efficient compressor. It would run all the time. So efficiency must be weighed with other factors.

Each compressor's score is based on a number of factors and changes dynamically through time. The score comprehends maintenance factors. For example, say that a particular compressor's oil must be changed every 8,000 hours of operation. The controller keeps track of this schedule and as the compressor usage approaches 8,000 hours, the maintenance factor starts to affect the overall score that determines when that compressor will run.

The PL4000 control system is also able to accept user defined inputs, which can affect the decision as to which compressor to run according to special factors known by the plant operators. This feature can be used to test out different control strategies. For example, a particular compressor may be called upon based on the requirements of a specific piece of production equipment and the proximity of the compressor. Or, perhaps the 'coach' wants to say 'I know that the regular scoring algorithm says that you (the compressor) are due for a break, but I'm going to insist that you stay in the game a little longer.'

Pressure monitoring isn't enough.

Simply monitoring the pressure of the air supply at various places around the plant isn't enough to use in determining when to start additional compressors. With pressure monitoring only, by the time that a controller detects a low-pressure situation, starts a compressor, and it starts making air, the pressure might have dropped significantly below the setpoint to an undesirable level.

To protect against having the pressure drop below a certain minimum, possibly causing a malfunction of the production equipment, one could raise the threshold pressure at which additional compressors come on, but the effect of this is to run the compressed air system at an average pressure level that is higher than necessary. This wastes energy and may result in the factory purchasing and maintaining more compressors than it needs. Maintenance costs can also increase needlessly due to air leaks and compressor wear caused by running the system at too high a pressure.

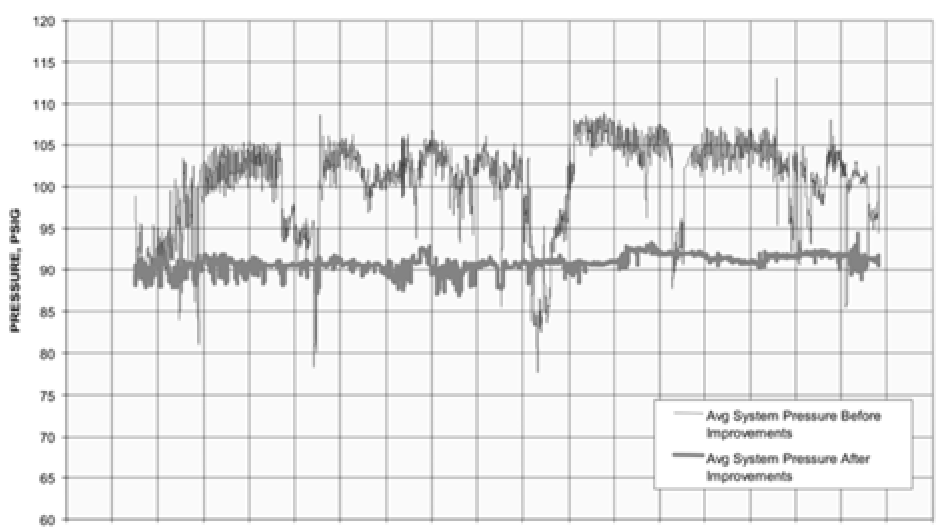
The solution is to use the flow of air, not just the pressure. With this additional data, the control system can predict when the pressure would cross the low-pressure threshold, and use that information to start additional compressors, if necessary, and give them time to ramp up to speed before the pressure threshold is reached. The control system can also factor the production load into the control decisions that it makes.

Figure 2 below shows the beneficial effect of active compressor control. Controlling flow and pressure avoids pressure spikes and enables the system to run at a much more stable pressure level that is lower than that of a system without active controls. As the diagram suggests, Pneu-Logic control systems can reduce the energy consumption of compressed air systems by 15-40%.

FIGURE 2.

COMPRESSED AIR SYSTEM PRESSURE BEFORE AND AFTER IMPROVEMENTS

The upper line reflects system pressure without active control. The lower line shows how the addition of a Pneu-Logic 4000 controller can smooth out the system pressure and enable the system to operate at a lower overall average pressure.



Patented Airgonomic™ algorithms

The control algorithms required to perform this task smoothly and economically are complex, and Pneu-Logic has patented the algorithms that are processed by its PL4000 control system. The control approach has been named Airgonomics™ because it maximizes the efficiency and productivity of a factory's compressor equipment while managing the supply and demand for compressed air.

Building networks of compressors

With the ability to monitor and respond to multiple air pressure and flow sensors comes the ability to also manage different pressure levels throughout a plant. A factory’s compressors and compressed air delivery systems can be organized into networks that may be optimized to use energy most efficiently, and to provide backup air sources when needed. The control system can take inputs from certain zones of the plant, certain pieces of equipment, production lines or machine centers, and provide just the right amount of air at just the right time to meet those needs. Zones supporting inactive production lines can be closed off. Figure 3 provides an example of the type of pneumatic network that can be constructed.

FIGURE 3.

ZONED SYSTEM

The controller can manage a network that supplies compressed air to different parts of the factory.

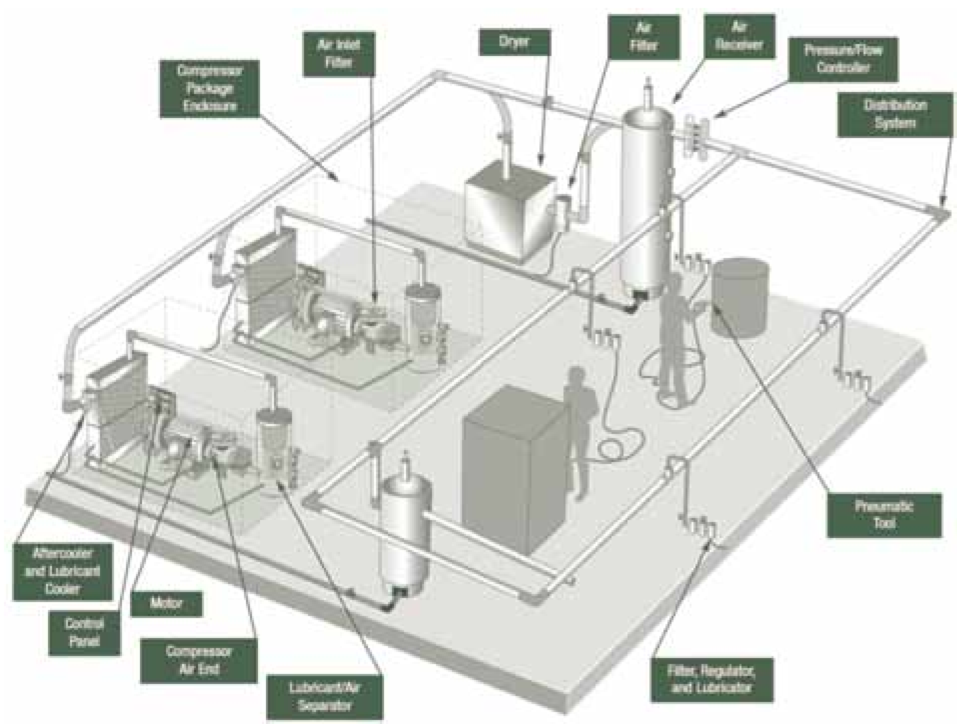


Figure 3: Courtesy of ***Compressed Air Challenge***

Active control capability can also allow for additional factors to be rolled into the control equation, beyond air pressure and flow. For example, the control algorithms can be adjusted to factor in the cost of electricity that might be different at different times during the day, or the strategies for selecting specific compressors to run can be changed over time as a factory’s production mix changes – proactively selecting a “recipe” that describes the compressed air resource that is required to serve a particular production run. Alternately, the mix of compressors needed to serve a particular work shift can be set up to support a specific maintenance strategy.

Intelligent controls can also help plant maintenance staff implement preventive maintenance programs. For example, these controls can monitor compressed air usage in a particular zone, making sure that one zone is not beginning to creep up versus that of other zones, which could be an indicator of a maintenance issue such as an excessive leak. Alternately, if the pressure in a zone decreases but production has not changed, the controller might suggest that a problem such as constriction in the lines due to corrosion or fouling is occurring.

In the old days, when compressed air systems were governed by mechanical pressure valves and gauges, such flexibility was difficult or impossible to manage reliably and repeatedly. Problems such as compressors running at only part of their capacity due to incorrect local pressure settings would go unnoticed. It was much easier for plant managers just to buy more compressors to solve low-pressure problems.

What about one- and two-compressor systems?

Even simple, 2-compressor systems can benefit from active controls. Say the first compressor is a large one and the second is a small one. The controller can make decisions based on air flow measurements to shut off the large compressor when system flow is low, and turn on the large compressor when the flow increases. For maximum air requirements, both compressors would be activated.

Compressed air as a renewable resource

There's a saying in the industry that 'If you don't remove the compressed air, you don't have to put it back.' And a corollary to this rule is, 'If there's no compressed air being used, then you must not need to compress any more to refill the pipe.'

The old way of viewing compressed air as a simple factory expense is giving way to the new understanding that compressed air is an expensive resource that must be conserved and managed. That's how Pneu-Logic sees it.

We believe in the saying - 'If you measure it, you can manage it.' Making intelligent decisions leads to decreased energy and maintenance costs, increased bottom line, and a lighter load on the environment.

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PNEU LOGIC

Pneu-Logic Corporation
6650 SW Redwood Lane
Suite 390
Portland, OR 97224

Toll Free: 866.348.5669

www.pneulogic.com