GENERAL DYNAMICS
Electric Boat

Air Compressors

Even air costs money

Bob Wolff

System Overview

- The Quonset Facility is split into two campuses; each campus has its own compressed air system.
- On the Bldg 60 side, there are four 150-HP reciprocating air compressors in two compressor rooms. The two compressor rooms are interconnected so that air can be provided from either room.
- On the Waterfront, there are five 300-HP reciprocating compressors in two compressor rooms, also interconnected.
- The overall compressed air generation capacity totals nine compressors, or 2,100 HP, capable of flowing 10,500 CFM at maximum demand.

Holding a Steady Pressure

- The compressed air system maintains a delivery pressure of 90 psig at all locations at all times.
- Compressed air systems are extremely dynamic – loads vary constantly and significantly throughout the day.
- Demand can suddenly increase dramatically creating a substantial load on the system.
- This causes system pressure to drop until the compressors can compensate and “catch-up”.
- CNC machines in the Machine Shop utilize compressed air for a wide range of internal machine operations. A drop in system pressure can cause these machines to fault, completely stopping their operation.

Be Prepared…..to pay

- To prevent such production shut downs, Maintenance worked hard to ensure that there was always an adequate supply of air available throughout the plant.
- They did this by running all 9 compressors 24 hours per day.
- When system demand was low, most of the compressors sat idling unloaded, with maybe 2 or 3 compressors running in a loaded condition to maintain the system pressure.
- But during heavy demand periods, the idle compressors would load up to help compensate for the pressure drop.
- Unfortunately this is an extremely expensive way to operate; a compressor running unloaded at idle is still consuming copious amounts of energy, but with no work being performed it is a 100% waste of energy.

Paying the piper

- Air compressors generate extreme heat and pressure leaving them subject to mechanical failures.
- They demanded a lot of hand's-on attention; so much so that there was always at least one maintenance mechanic assigned to air compressor rounds – 7 days a week, 24 hours a day.
- The mechanic's sole responsibility was to go to each compressor room to check every compressor. All of the operating parameters were checked such as oil pressure, intercooler pressure, cylinder water temperature, etc.
- He would also add oil and perform any repairs or maintenance or re-start any compressor that may have tripped offline.
- It was an expensive way to run the system, but the price of stopping production due to loss of air pressure was considerably higher, so it became an acceptable expense.

Trim those sails

- As air compressors have such a large impact on energy use with their huge electric motors, it seemed a logical place to look for energy savings.
- In conjunction with the utility, a 3rd party engineering firm was brought in to perform a detailed analysis of the compressed air system.
- They installed electric metering along with air flow sensors on the system for ten days and studied demand and loading of the system.
- They quickly realized that many of the compressors were not performing any work but were still consuming energy.
- They formulated a plan to centralize control of the compressor so that compressors would not run when there was no need to do so, but would automatically start when needed.

Don’t reinvent the wheel

- When the Energy Management System was setup with the chiller project, the infancy of a EMS network had been created.
- So when the utility offered EB significant rebate money to install a central control system for the air compressor, we accepted.
- They recommended the installation of a stand alone system designed for air compressors. But with the EMS already in place, adding another system was not the right way to proceed. We decided that the EMS would take over control of the air compressor.
- We located a contractor that was familiar with building automation systems (including Carrier), had some knowledge of air compressors and air systems, and had both the mechanics and electricians on-staff to handle such a project.

Wired……

- Each compressor was wired for full automatic operation and monitoring, Sensors were installed for all critical components, including additional sensors to monitor things such as machine vibration that were not part of the original compressor design.
- Every point on the compressor being monitored could be setup in the EMS to signal an alarm should that point drift out of its predetermined parameters. For example if the optimal oil pressure for a specific machine is between 20 – 35 psig, the computer was setup to signal am alarm if the pressure dipped below 20 or above 35.
- In fact, taking a step further, the computer could be programmed to actually shut the machine down if the pressure continued to fall, or even if it stayed steady, but below, setpoint for a set amount of time.

Keeping the wind in the sails

- The EMS uses PID-based (proportional-integral-derivative) algorithms for precise control.

- These algorithms calculate deviation of a process variable from a variable setpoint using mathematical equations.

- Factors such as extent of error, rate of error acceleration, and total time of error are used to determine how quickly, and how extensively to apply correction to the control device.

- Using this function, the EMS reads system air pressure and when an additional compressor is required based upon a drop in system pressure, it stages in a trim compressor.

Don’t overfill the balloon

- This process continues with the EMS staging in additional compressors until the system pressure stops falling and begins climbing back towards normal.
- At this point, the EMS begins shutting compressors down so as to avoid over pressurizing the system.
- No trim compressor is permitted to start unless the preceding compressor is running at full load. This avoids the wasted energy of running two compressors partially loaded.
- Additionally, dead bands are utilized to avoid damage to the compressors that would be caused by short-cycling them

Air isn't free?

- The price to install all of the sensors, wiring, controls, and custom programming in the EMS came in just under $190,000.
- Due to the energy savings, the utility paid a $94,000 rebate to EB to help offset the project cost, leaving a net cost of approx. $96,000 to EB.
- The annual energy savings due to the project were initially estimated at 760,000 kWH, worth $52,000 in 1998 energy dollars.
- The actual savings proved to be even higher than estimated, approaching 800,000 kWH annually. Using 2006 energy dollars that reduction equals almost $100,000 per year.
- In the 8 years since the completion of the project, Electric Boat has enjoyed a cost avoidance of $488,224 in electrical bills.

Like free pie and chips…

- Additional benefits:
  - A maintenance person is no longer required for air compressor duty. One person on 3rd shift stops at every compressor to check oil and add as necessary. His total time for all nine compressors is approx 1 hour – a remarkable labor savings of 23 hours per day!
  - As they are no longer running constantly, compressors are lasting mechanically longer than ever. Repair costs are down almost 200%.
  - Thanks to the highly precise control, yard air pressure rarely varies by more than 5 psig at any time.
  - All OEM safeties related to safe operation of the compressors were retained so that any compressor could still shut itself down as required. But with these same safeties now also wired into the EMS, the Facility Engineer is instantly notified if a compressor shuts down.

Kudos

November 1998

Expanding Energy Efficiency Frontiers

A newsletter from DMI and Peter Barrer

Massive metering makes $52,000 available in annual savings

A large-equipment manufacturer with multiple buildings and multiple interconnected compressed air systems was looking to reduce operating costs and invited DMI to survey the compressed air systems.

The plant contained nine air compressors (up to 300 hp in size) in different locations, some serving the same load. To get a handle on actual operations, we electrically metered all nine air compressors for ten days. We theorized that a central control system that cycled off compressors based on the actual requirement for compressed air would significantly reduce operating costs. The metering results confirmed our concept. In addition, metering results enabled us to recommend efficient replacement equipment for most of the compressed air dryers. Assisted by a utility rebate, the manufacturer has installed both recommendations and expects annual savings of 760,000 kWh, worth $52,000. The manufacturer was also pleased with how the monitoring function of the control system has reduced routine tours at every shift to the various compressor rooms, eliminating a significant task for plant personnel.

Wasting less and doing more

A wastewater treatment plant was considering installing VSDs on its 200 hp and 300 hp influent pumps, and asked DMI to estimate the energy savings value of the installation. As part of our evaluation, we compared present pump performance to original design specifications. Although pump power and flow were as expected, we found that pump pressure was significantly below original design. We recommended a pump adjustment and arranged for the manufacturer's representative to visit the plant and discuss the adjustment with the maintenance personnel. When the adjustment was completed, we found a performance improvement of 11%, which was much greater than would have been expected with the variable drives. The facility immediately enjoyed greater savings, at much less cost, and avoided the trouble of installing the proposed new equipment.

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QUESTIONS

- This concludes the presentation. If you have any questions you wish to ask, now is a great time to do so.