Improving industrial productivity through energy efficient advancements

energy savers

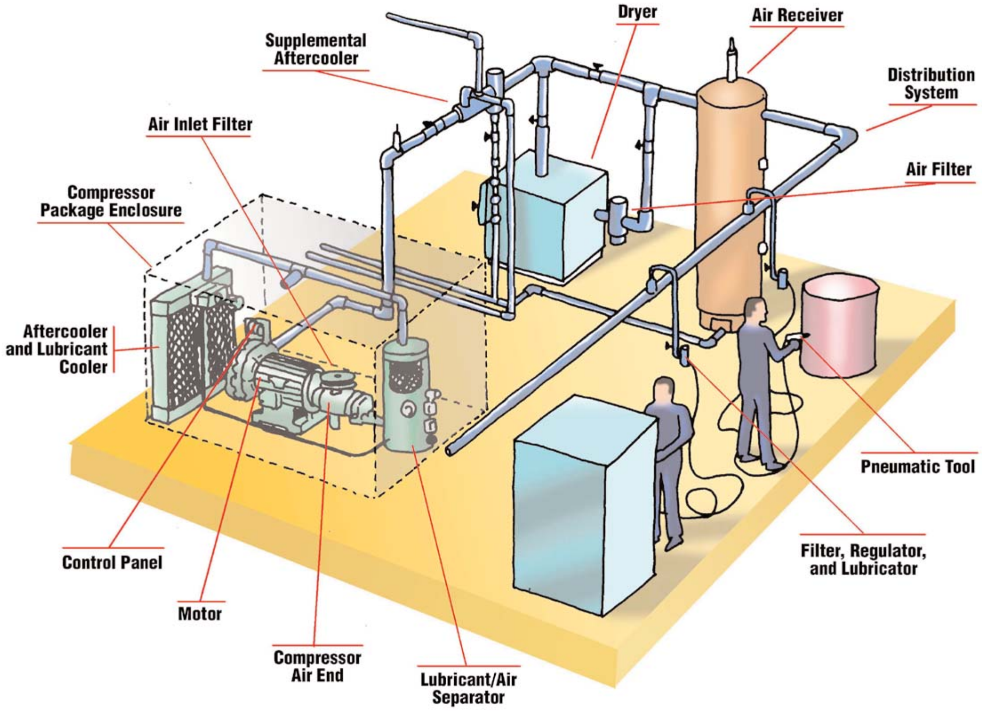

Figure 1
Basic compressed air system

Compressed Air

Compressed air is a power source widely used in industry to power tools and in many types of conveyors, manufacturing and converting processes, and processes such as filtration, refrigeration, and aeration. While other utilities such as electricity, natural gas, and water are often purchased from outside the industrial facility, compressed air, sometimes called the "fourth utility" is almost always manufactured on site.

Because compressed air is generated on site, the cost of its production is often overlooked or unknown. This results in a common perception that compressed air is free. Unfortunately it isn't. Many estimates place the cost of using compressed air at nine times the cost of using another direct utility such as electricity! This is because

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of the inefficiencies of the motor running the compressor, the compressor itself, leaks in the system, friction loss in the piping, air pressure reductions, and the inefficiencies of the device or process where the compressed air is finally applied. Because compressed air can be so expensive, it should be used efficiently and wisely.

Concepts

The basic compressed air system consists of a compressor, a prime mover, controls, air treatment equipment and accessories, and the air distribution subsystem. A basic compressed air system is shown in Figure 1. Through understanding each of these components and their propensity for inefficiencies, appropriate system applications and maintenance schedules can be instituted, allowing high system efficiencies and lower system costs.

- Compressors

  While multi-stage compressors are the most efficient, single stage compressors are more common in industry because they have lower manufacturing costs. Multi-stage compressors gain their advantage through having smaller pressure steps in each stage and cooling the air between stages, or reducing the volume that needs to be compressed. However, due to initial and maintenance costs, usually single-stage compressors are installed. In industry, rotary positive-displacement compressors are preferred over reciprocating compressors because they are smaller and do not suffer pressure pulsations like reciprocating compressors. Centrifugal compressors are optimal in large, constant load applications.

- Prime Movers

  The prime mover, or force, behind 90% of compressors in industry is the electric induction motor. Due to the Energy Policy Act laws of 1997 and the NEMA Premium Standard, general-purpose motors within the 1-Hp to 200-Hp range are energy efficient. A rule of thumb for motors is $1. Up to $1 can be saved annually per horsepower per point of efficiency. In other words, if choosing between two 100-Hp motors with efficiencies of 94.6% and 93.0%, respectively, the more efficient motor can cost up to $160 more than the less efficient motor and be economically equal investments in the first year.

- Controls

  Control mechanisms regulate flow so that compressed air volume and pressure meet facility needs. There is a cubic relationship between volume flow and power required; therefore, maintaining the lowest flow necessary to match facility needs at any point in time yields considerable energy savings. Also, controls can coordinate multiple compressor systems for lowest energy usage.

- Air Treatment Equipment

  In compressing air, the pressure is raised and the dew point drops. As a result, water can condense or be considerably more humid in compressed air than in the source air. As a result, dryers and filters are employed to process compressed air for water and other residues that could be deposited and reduce flow in the compressed air distribution system.

One of the first issues in evaluating the cost of compressed air usage is the level of purification required for the air. As greater levels of treatment are necessary, the cost of producing each cubic foot of air increases. These treatment levels can vary from general plant air used to run tools and other pneumatics to breathing air used in hospital systems, diving tanks, etc. In between these two extremes are instrument air, which may be used for spraying paint or climate control, and process air used in such industries as food and electronics. In general, the best practice is to treat only the required amount of air to the minimum level necessary for the use.

Receivers and other storage tanks allow compressed air to be "saved" so that when a high demand is needed, air can be supplied without pressure fluctuations. Because the production of heat is always associated with the compression of air, it is often cost effective to recover this "waste heat" and use it in a process. The heat can supply some space heating during the appropriate seasons, heat water or other fluids, or be recovered for some other useful purpose.

- Air Distribution Subsystem

Once leaving the compressor, compressed and treated air travels through the air distribution subsystem to reach its final application. Most compressor system efficiency is lost in the air distribution subsystem: As air travels through a maze of trunks, hoses, and valves, there is considerable pressure loss, and so compressors must be oversized so that the final pressure meets the facility's needs. Additionally, the air distribution subsystem is most vulnerable to leaks. Leaks can cost a facility thousands of dollars per year in lost compressed air energy. Leaks are specifically discussed under "Compressed Air Issues."

Often compressed air is used instead of a less costly alternative. For example, using compressed air vortex tubes to cool electrical cabinets is more costly than using fans or air conditioning. Instead of expensive compressed air, it is more cost effective to use blowers to provide cooling, aspirating, agitating, mixing or inflating. Parts should be cleaned with brushes, blowers, or vacuums instead of with compressed air. Table 1 compares suggests alternatives to common, inappropriate uses of compressed air. Often, efficient electric motors for tools are a much lower cost choice than are compressed air tools.

In addition to inappropriate uses, compressing air to higher system pressures than necessary will significantly increase costs. System operating costs increase by about 1% for every 2 psig at around 100 psig. For example, it takes about 10% more energy to use the same volume of air at 110 psig than the same volume at 90 psig. It is therefore most cost effective to run a compressed air system at the lowest pressures possible. In many cases it is possible to decrease pressures at some or many points in the system. However, this must be done with extreme caution because it is common for some critical plant processes to be adversely effected by reducing pressure. If a pressure reduction program is initiated to reduce costs, it can quickly be "killed" the first time a process problem is related to low compressed air pressure. Additionally, if one process requires significantly higher pressures than all other facility applications, consider installing a separate compressor for that process, and turning down the general system pressure.

Table 1: Inappropriate compressed air applications	
Inappropriate Uses	**Appropriate Alternatives**
Clean-up, Drying, Process cooling	Low pressure blowers, electric fans, brooms, nozzles
Sparging	Low pressure blowers and mixers
Aspirating, Atomizing	Low pressure blowers
Padding	Low to medium pressure blowers
Vacuum generator	Dedicated vacuum pump or central vacuum system
Personnel cooling	Electric fans
Compressed air operated cabinet coolers	Air-to-air heat exchangers or air conditioners
Air motor driven mixer	Electric motor driven mixer
Air operated diaphragm pumps	Proper regulator and speed control, electric pump
Idle equipment	Put an air-stop valve at the compressed air inlet
Abandoned equipment	Disconnect air supply to the equipment

Table 2: Lost air costs for varying supply pressures and equivalent orifice sizes*

Orifice Diameter	Pressure (psi)	Cost at $0.05/kWh	Cost at $0.08/kWh	Cost at $0.10/kWh
1/16"	25	$51	$82	$102
	50	$166	$266	$332
	100	$589	$942	$1,178
	125	$896	$1,433	$1,792
1/8"	25	$204	$326	$407
	50	$667	$1,067	$1,334
	100	$2,359	$3,774	$4,718
	125	$3,584	$5,734	$7,167
1/4"	25	$814	$1,303	$1,629
	50	$2,658	$4,253	$5,316
	100	$9,435	$15,097	$18,871
	125	$14,289	$22,863	$28,578
1/2"	25	$3,266	$5,226	$6,532
	50	$10,660	$17,056	$21,320
	100	$37,651	$60,241	$75,302
	125	$57,384	$91,814	$114,767

* Assumes 8,760 annual hours and 90% compressor efficiency

Moreover, compressed air leaks are a significant contributor to overall compressed air costs. For example, a system operating at 100 psi will lose about 26 cfm per minute through a 1/8" leak. A leak this size will cost a facility approximately $2,000 per year, as shown in Table 2. Leak repair is not as straightforward as it may seem, as some leaks cannot be detected without the use of ultrasonic devices. Also any significant reductions in system power requirements are usually not realized until a majority of the leaks in a system are repaired.

Summary

Compressed air systems are important and necessary components of modern industry. However, these systems are costly to maintain and operate. If compressed air systems are managed so that the air is properly controlled, treated, and used, significant savings can result.

Resources

"Compressed Air Systems Fact Sheet #11: Proven Opportunities at the Component Level." Compressed Air Challenge, Office of Industrial Technology.

"Improving Compressed Air System Performance: A Sourcebook for the Industry." Motor Challenge and Compressed Air Challenge, April 1998.

"Eliminate Compressed Air Leaks." National Energy Conservation Centre.

www.peemac.sdnpk.org/resource/pdf/tip26.pdf

"Maintaining Energy-Efficient Industrial Compressed Air Systems." EPRI, 1991.

www.compressedairchallenge.org

FOR ADDITIONAL INFORMATION ABOUT *Compressed Air*, contact your Progress Energy representative.