Eskom
Compressed Air: Industrial sector

Fact Sheet

Introduction

1

Compressed air is used widely in industry, but it is a very expensive process, and as such efficient utilization is important. There is a tendency to believe that compressed air is cheap, however in many industrial applications less than 5% of the energy consumed by air compressors is actually available for work at the point of use.

The performance of a compressed air system is heavily dependent on the level of air leakages. This can be assessed by measuring the energy consumption of the plant during periods when there is no demand for air, typically over weekends or during shift changes. The rate of energy consumption during these periods is the base load of the system and can only be reduced by limiting air leakages, or installing a more efficient compressor plant. The remaining energy consumption will be related to usage, measured by production rate or site activity.

Generally, 30% of total electrical energy used to compress air is wasted, due to air leaks, poor maintenance, misapplication and poor control, and potential savings could be reaped by introducing simple, cost-effective measures that minimize this avoidable wastage.

Employing energy management practices will benefit industry by optimising systems and reducing power consumption without compromising production.

This information brochure aims to assist industrial and commercial users of electricity to improve the energy efficiency of compressed air systems. It explains the benefits of optimising the energy efficiency of these systems and explains common problems affecting efficiency before describing a number of measures to improve operating efficiency, and thereby, reducing electricity usage and costs. It concludes with a summary checklist and details of a free energy advisory service available from Eskom.

Compressed air systems

2

Air compressors are used to operate air-powered equipment and fill inflatable objects. Various sizes and types are available, depending on the nature of the jobs they are needed for. Air compressors are mechanical devices that draw in air and discharge it at a higher pressure, usually into a piping system or storage tank. Compressors can be described as either positive displacement (using pistons or rotors) or dynamic (using impellers or blades).

In positive displacement systems, reciprocating and rotary screw compressors are the most common. Although compressors are driven by a variety of motors, including internal combustion and steam engines, electrically driven motors are most common and offer the opportunity for efficiency gains that will result in energy savings.

Compressor controls

3

Understanding the methods of controlling compressor output provides the necessary insight into how these systems can be optimised. Four methods are used:

- Constant speed unloading controls: these are usually pressure sensitive and reduce the output of the compressor to match the load.
- Start-stop controls: usually a pressure sensing switch, where the controls stop and start the compressor as required to meet system load.
- Dual controls: this is a combination of the two methods above.
- Variable speed control: no unnecessary power is consumed, matching usage to requirement.

One type of unloading control cycles is to set the compressor between full output and idle; either the compressor works at full output when the system pressure reaches the low pressure set point, or it is completely off at the upper pressure set point. This control mode is commonly applied in both reciprocating and screw compressors; energy consumption is proportional to the reduced load.

Another type of unloading control is modulated output. This continuously regulates the compressor output to maintain a set system pressure. Inlet throttling employs a variable-opening valve at the compressor inlet. This method has relatively high "off-load" energy consumption. With bypass control, the compressor operates at full load all the time and excess air from the discharge is bypassed back to the inlet. In these controls, energy consumption is high and excess heat is generated which must be removed from the air.

The Variable Speed Drive (VSD) concept simply measures the system pressure and maintains constant delivery pressure within a narrow pressure band. This is achieved by regulating the motor speed of the compressor, which results in a varying air flow delivery. VSDs can not be used for reciprocating compressors.

Energy-saving opportunities

4

The factors that are most commonly found to be responsible for energy losses are air leaks, unnecessary use of compressed air for cleaning, and improper system layout. A properly designed and maintained compressed air system can contribute significantly to improving the energy efficiency of an operation. Most of the interventions that can result in improvements in electricity consumption are basic maintenance procedures, in support of an energy management plan, which also support improved longevity and performance of essential industrial equipment. Meanwhile, reducing electricity consumption also contributes towards lower environmental impact.

The main cost of compressed air is the electrical energy required to operate the compressor. Power required is largely determined by the system pressure, the initial air temperature and pressure, and the integrity (airtight quality) of the system.

All these factors can be controlled within given constraints to minimise energy costs. In plain terms, the electricity consumption of the compressed air system can be reduced and optimised by:

- Optimising air usage;
- Reducing air leakage;
- Optimising system operating pressure;
- Reducing compressor inlet temperature; and
- Increasing compressor inlet pressure.

Air usage

The air used by industrial systems that are powered by the compressor is obviously the largest component of the overall cost. Assuming process requirements for compressed air are fixed, there is little that can be done to reduce this cost factor. However, peripheral activities in which compressed air is used can be eliminated, such as employees using air for activities such as cleaning dusty surfaces and clothes. This misuse, as well as other examples of mishandling, can lead to unnecessary energy consumption that can result in increased energy costs.

Unregulated end-uses

A pressure regulator is used to limit maximum end-of-use pressure and is placed in the distribution system just prior to the tool. If a tool operates without a regulator, it uses full system pressure. This results in increased system air demand and energy use, since the tool is using air at this higher pressure. High-pressure levels can also increase equipment wear, resulting in higher maintenance costs, and shorter tool life.

Abandoned equipment

Many plants undergo numerous equipment configuration changes over time. In some cases, plant equipment is no longer used. Airflow to this unused equipment should be stopped, preferably as far back in the distribution system as possible, without affecting operating equipment.

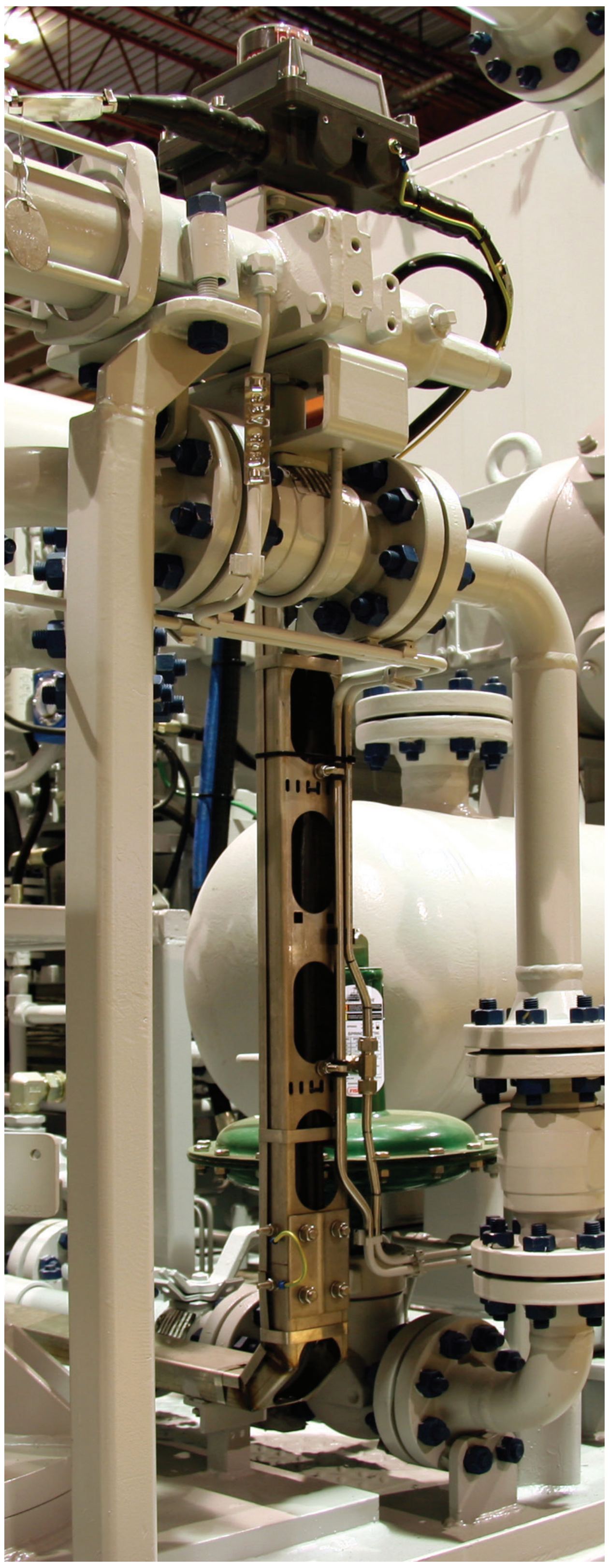
Periods when compressed air is not required

Another common malpractice is to generate compressed air at times when it is not needed. In many cases there is no need for compressed air at all during non-production hours, but compressors are often not switched off.

Air leakage

Although compressed air leaks often go unnoticed because they are invisible and usually masked by plant noise, they are the most frequent and expensive defect in compressed air systems, resulting in loss of air capacity and increased energy consumption. If there is any leakage in the holding tanks or piping systems, it will require the compressor motor to work harder in order to maintain pressure, hence driving up the electricity cost.

Identifying and eliminating unnecessary leakage is therefore a simple and sensible tactic to reduce the energy cost of the system. While completely airtight systems are not typically practical, a maximum loss of 5% of compressor capacity is considered acceptable. However, many systems experience losses of as much as 20% or more due, to air leakage. Eliminating leakages also reduces the work required from the compressor, contributing to improved equipment longevity.



Leaks can be a significant source of wasted energy in an industrial compressed air system, sometimes wasting 20% or more of a compressor's output.

Hole Diameter	Air leakage at pressure of 7 bar	Amount of power wasted	Total energy wasted @ 2000 hr/annum	Annual cost due to leaks @ R1/kWh
mm	l/s	kW	KWh	R
0.4 (pin head)	0.2	0.1	200	R 200
1.6 (pin head)	3.1	1.0	2000	R 2 000
3.0 (pin head)	11.0	3.5	7000	R 7 000

***Table 1** gives an example of how even very small holes can contribute to energy wastage.*

A typical plant that has not been well maintained and does not have active monitoring, will likely have a leak rate equal to 20% of total compressed air production capacity. On the other hand, active leak detection and repair can reduce leaks to less than 10% of compressor output. The first step in tackling leaks is to recognise the costs involved and make a commitment to a plant-wide awareness programme. Regular, continuous attention to the compressed air system coupled with proper maintenance will lead to effective progress in minimising leaks.

Suitably qualified professionals should conduct testing for leaks in compressor systems regularly. While leakage can come from any part of the system, the most common problem areas are:

- Couplings, hoses, tubes, and fittings
- Open condensate traps and shut-off valves
- Pipe joints, disconnects, and thread sealant
- Leaking pressure regulators
- Air cooling lines left open permanently
- Air using equipment left in operation when not needed.

System operating pressure

The system operating pressure is usually set as required by the industrial processes that are driven by compressed air. While there is often little scope for improving performance in this area, the mere checking and confirming that the system is not operating at a greater pressure than is required, ensures optimal efficiency.

Additionally, since air pipe work losses cause a reduction in delivered pressure, it should be noted that this loss could be excessive if the distribution piping is undersized or poorly routed. To provide the required end-use pressure, the system pressure at the compressor must be increased to compensate for distribution losses. Thus, improved pipe work designs will reduce power requirements.

Inlet air temperature

Since warmer air is less dense, and the purpose of a compressor system is to achieve more dense air, it follows that reducing the temperature of intake air will lower the power required on the compressor.

This can often be accomplished by simply installing an air intake duct from outside the building instead of drawing air from the warmer plant environment.

Inlet air pressure

If the pressure of the inlet air can be raised, there will be a decrease in the required compression power for the same airflow capacity and discharge pressure. This can be accomplished by ensuring that intake filters are replaced when dirty; or in accordance with a routine maintenance schedule, and also by ensuring that ductwork does not obstruct airflow at the intake.

Maintenance and optimisation: contributing to reduced energy consumption

By implementing sound maintenance programmes and ensuring that compressed air systems are optimised and appropriately configured for the task at hand, industrial electricity consumers can reduce their power bills while improving the performance and longevity of essential equipment. These interventions are generally 'common sense' approaches; with the assistance of specialists, accurate measurements can be taken and actual savings accurately calculated to assess feasibility. Industrial clients can ensure that their overheads do not increase dramatically by optimising equipment operation and maintenance. The result is the possibility of sustaining productivity at current levels without experiencing a dramatic increase in input costs.

Variable speed drives on compressors

Traditional compressors working on a full load with no load control, operate between two set pressure points. When maximum pressure is reached the compressor goes off load. During periods of medium to low demand, the no-load power consumption can be excessive – wasting large amounts of energy.

With a VSD no unnecessary power is consumed, and energy costs are significantly reduced. The VSD concept simply measures the system pressure and maintains a constant delivery pressure within a narrow pressure band. This is achieved by regulating the motor speed of the compressor, which results in a varying air flow delivery. VSD's can not be used for reciprocating compressors.

Before

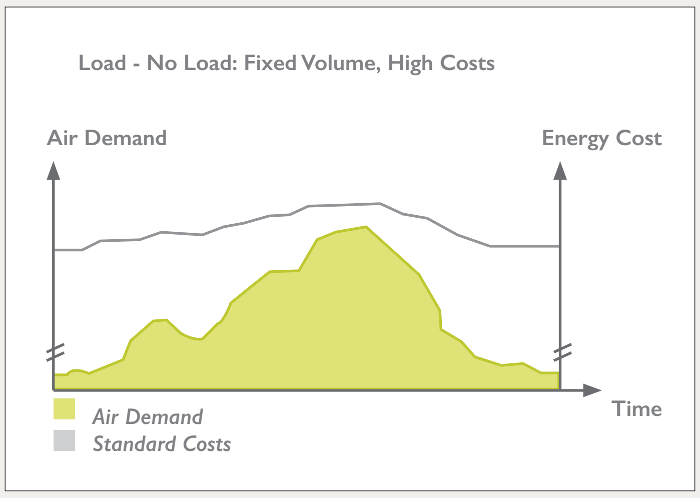


Figure 1: Fixed speed air compressor [6]

After

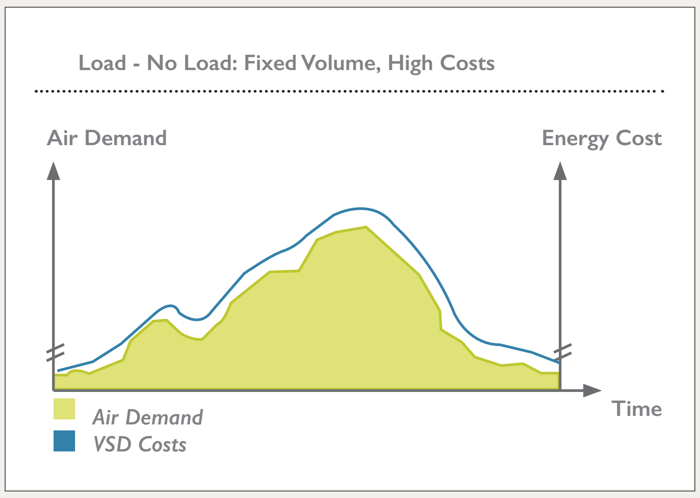


Figure 2: Variable speed air compressor [6]

The inverter in the VSD system performs a "soft" start operation by ramping up the motor speed, thus eliminating amperage draw peaks that are typical when a fixed speed motor is started. The soft starting utilized by a VSD compressor also helps protect electrical and mechanical components from the starting mechanical stresses that can shorten the life of an air compressor.

Correct sizing of compressors

Compressors should be sized as closely as possible to the performance requirement. It is not economical to run any machine for long periods at low loads, due to electric motor inefficiencies. The off-load power can be 15%-70% of the on-load power once motor inefficiencies have been taken into account. For new installations with multiple compressors, it is worthwhile considering installation of a selection of unit sizes, so those compressors operating close to full output can meet the demand.

Energy Advisory Service 5

Eskom's Energy Advisors, in regions across South Africa, offer advice to business customers on how to optimise their energy use by:

- Understanding their energy needs;
- Understanding their electrical systems and processes;
- Investigating the latest technology and process developments,
- Analysing how to reduce energy investment costs; and
- Optimising energy use patterns in order to grow businesses and industries

Call **08600 37566**, leave your name and number and request that an Energy Advisor in your region contacts you. Visit **www.eskom.co.za/advisoryservice** for more information.

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