KAESER COMPRESSORS®
Built for a lifetime.

# The Proper Application of Rotary Lobe and Rotary Screw Blower Technology

*Stephen Horne, Product Manager - Blowers*
*KAESER COMPRESSORS, INC.*

*Marcus Jungkunst, Product Manager - Turbo Blowers*
*KAESER KOMPRESSOREN SE*

The wide range of low pressure technology available offers numerous choices when it comes to efficiently meeting the needs of low pressure applications. Indeed, for most applications, there are several technologies capable of powering a specific installation. The challenge is to closely examine the application needs and select the right technology to ensure a reliable, stable, and energy efficient air supply.

The advent of rotary screw blowers has been heralded as the energy efficient solution for most aeration and other low pressure processes. While this technology has the potential to significantly reduce energy costs and greatly improve system reliability, these promises are only achievable when the technology is properly applied.

This white paper will examine two common technologies found in wastewater and industrial processes: rotary lobe blowers and rotary screw blowers. In addition to comparing and contrasting the compression and efficiencies inherent with these two designs, this paper will open by defining ideal applications for both types of technology and close with operating case scenarios that illuminate proper application of both blower types.

## Package Integration

The scope of this white paper is limited to comparing rotary lobe and rotary screw blower integrated packages. This is significant as it is still a fairly common practice to specify and source individual blower package components and build the package from the ground up. This piecemeal approach to blower package design results in highly customized, one-off packages with components from multiple suppliers, making troubleshooting and technical support difficult. Further, it complicates accurately assessing the true package efficiency as each component contributes to the overall pressure drop and efficiency losses within the package.

Having a single-source package enables clear package efficiency testing, reporting, and evaluating, and greatly simplifies technical support and troubleshooting. There are advanced integrated packages that include controls to improve blower operation, enable performance monitoring, and allow integration into the IIoT and plant communications systems. For the purposes of this white paper, we are comparing integrated blower packages (which include an onboard package controller).

## Applications

Rotary lobe and rotary screw blowers utilize positive displacement. This means they pressurize air by trapping a fixed amount and forcing (or displacing) it into a discharge pipe. Industrial applications include fluid aeration (wastewater treatment, bioreactors, and flotation), process air, pneumatic conveying, as well as fluidization.

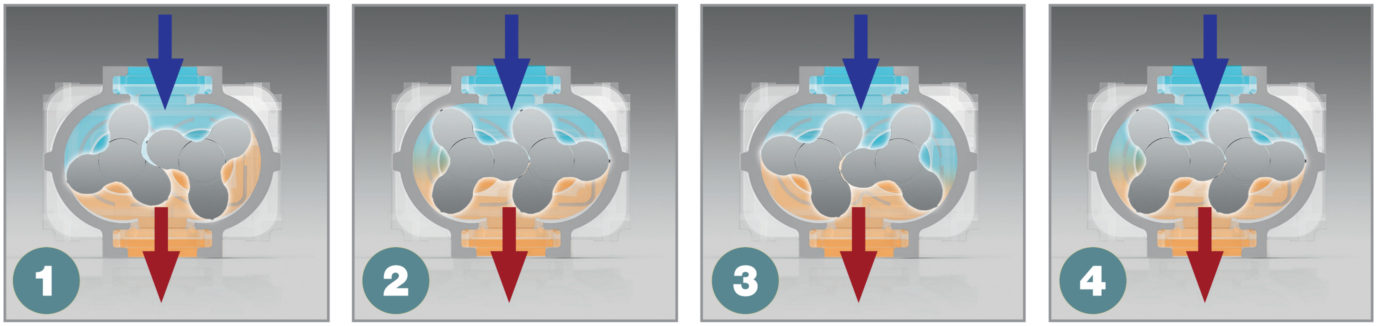

**IMAGE 1:** Pressure increasing - the images show the cross-section flow chamber of KAESER's rotary lobe blower block.

Although all of these applications generally operate within a low pressure range (up to 14.5 psi), most have vastly different running periods and load times. Fluid aeration applications in particular require a variable flow rate, yet have a virtually constant pressure profile.

Others, such as pneumatic conveying, require a near constant flow rate, even with high pressure fluctuations; at times they even require the blowers to idle, i.e. remain in operation without back pressure from the process side, such as when there are no bulk goods present in the supply line.

Naturally it's important to decide which blower technology is best suited to the application in question. Technical requirements must be taken into account, such as a broad flow rate control range and maximum stability of the flow rate curve during pressure fluctuations. Ultimately, the decision depends on the amount of energy savings achievable. In determining energy savings, the "power bill" is determined solely by output (kW) x time (h) x rate ($/kWh).

In other words, time significantly impacts energy costs. Sufficient load hours are needed for more efficient blowers to fully capitalize on their energy advantage.

## Isochoric Versus Isentropic Compression

To determine which of these blowers would be most cost effective for a given application, it is important to first understand in greater detail how each functions.

### Rotary lobe blowers

Image 1 shows a cross-section of the rotors and cylinders, running parallel in the longitudinal direction and illustrates how the size of the volume enclosed between the housing and the rotor blade remains constant. In thermodynamics, this is referred to as isochoric compression. The pressure does not build until the air molecules are successively pushed into the connected process line. In this way, with rotary lobe blowers, pressurization occurs externally. Moreover, if the process line is free of resistance (e.g. no bulk goods in the case of pneumatic conveying), there is virtually no back pressure since the blower continues to operate. In this regard, the rotary lobe blower can also be seen as adaptive: it only produces the amount of pressure needed.

### Screw blowers

With this blower design (image 2), the tried-and-trusted technology of the single-stage, oil-free screw compressor has been optimized for low pressures.

The rotor geometry is based on the screw. The inlet air is initially captured within the cavity between the two rotors where its volume is gradually decreased due to the counter-rotating rotors until it is pushed out through the discharge port. The geometry of the rotors and housing (i.e. contour of the discharge port) determine how much air is proportionally compressed within the screw blower and how much pressure is built up internally. This internal pressurization can also be called isentropic compression.

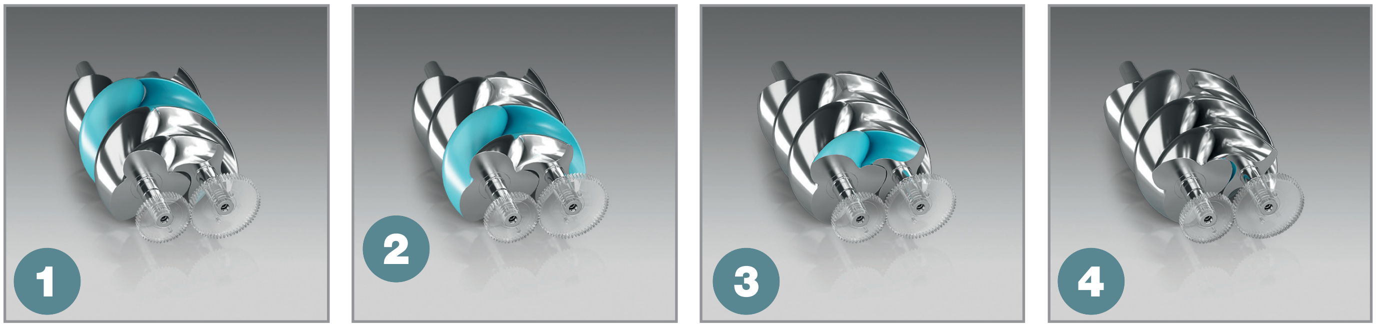

**IMAGE 2:** Pressure increasing — the images show the air volume being compressed via the dual rotors of KAESER's screw blower block.

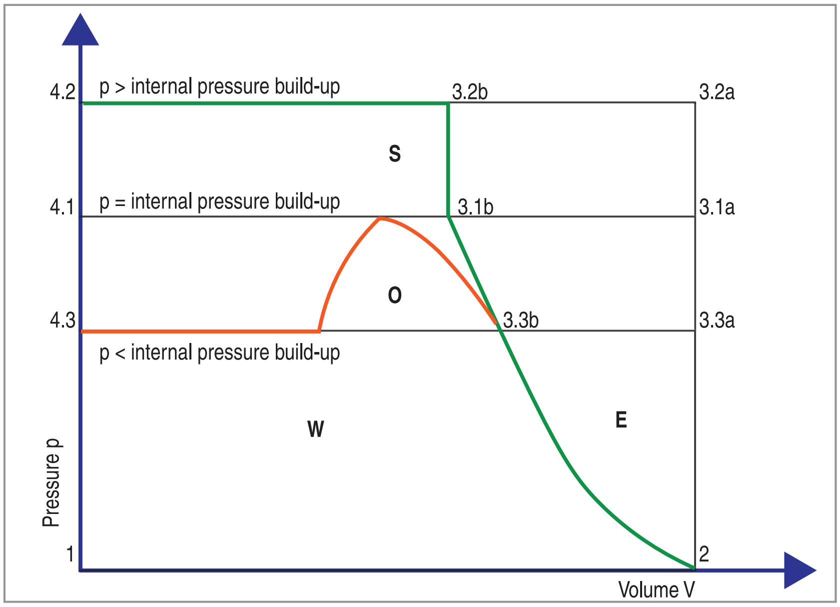

**DIAGRAM 1**

Pushing a gas whose volume has already been reduced in the screw blower against the system back pressure requires less energy and compression work than pushing the unreduced volume that is characteristic of isochoric compression (rotary lobe blower).

Moreover, both types of blower are dry-running, i.e. neither water nor oil is used as a cooling fluid within the housing, which reliably prevents air from coming into contact with these potential contaminants.

## Compression Process and Working Pressure Process

Diagram 1 (left) shows both compression technologies in a pressure-volume diagram. At Point 1, air is ingested the blower and at Point 2, following the capture of the gas volume; the blower's compression process begins. For the rotary lobe blower, the diagram is a rectangular box with the height of the box (3.Xa) equal to the system pressure. This demonstrates the adaptive nature of the rotary lobe design. For the screw blower, we find a curved line for the compression process (3.Xb), which demonstrates the internal compression process. These differences will be explained in further detail below.

The area enclosed by these lines represents the work of compression.

To further examine the characteristics of these curves, let us evaluate three separate compression cases. Case 1 will be if the screw blower's internal compression is equal to the working pressure. Case 2 will be if the working pressure is greater than the internal compression, and Case 3 where the working pressure is less than the internal compression of the screw blower.

### Case 1 – Working pressure is identical to the internal pressure of the screw blower (Diagram 2)

The rotary lobe blower conveys the full volume against pressure up to Point 3.1a and then discharges it (P 4.1). This creates a rectangular box defined by points 1, 2, 3.1a, and 4.1.

The screw blower conveys a steadily decreasing volume up to P 3.1b, and then discharges it (P 4.1). The area E between Points 2, 3.1a and 3.1b is the work of compression savings – as shown in the diagram, the screw blower achieves up to 30% savings in energy consumption compared to the lobe blower.

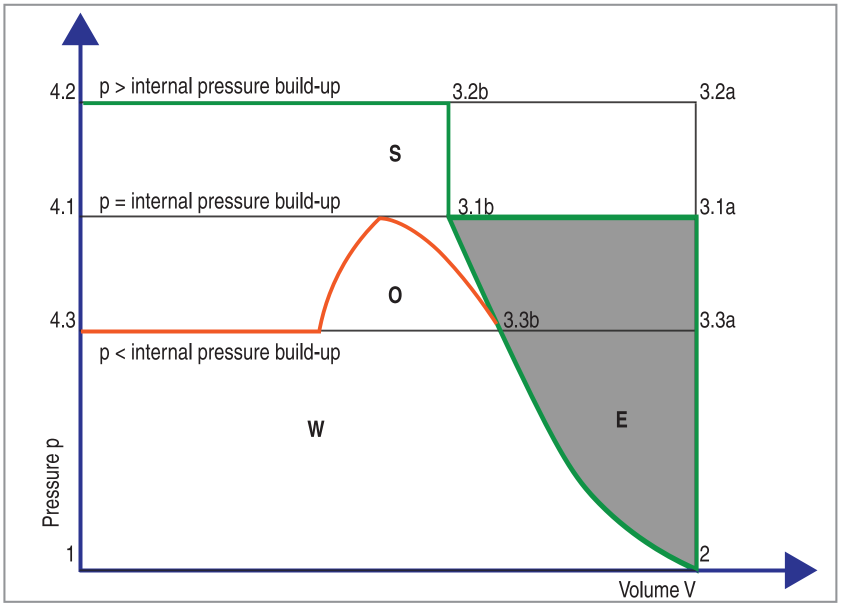

**DIAGRAM 2: CASE 1**

**Case 2 – Working pressure is higher than the internal pressure of the screw (Diagram 3).**

As with the prior case, the rotary lobe blower forms a vertical line from point 2 to system pressure at point 3.2a, before discharging at point 4.2, completing the rectangular box, and adjusting to the higher pressure. In this case, the screw blower must also isochorically discharge the volume against the remaining pressure difference, in a similar manner to the rotary lobe blower. This can be seen in the additional area S (shaded green), outlined by points 3.1b, 3.2b and 4.2. The internal compression of the screw blower reaches the maximum at point 3.1b, so the remaining compression must occur externally. This external pressure increase is seen from 3.1b to 3.2b.

Again, the screw blower significantly reduces the work of compression (grey shaded area E to the right of the green line) and therefore, the energy consumption – the higher the pressure, the better.

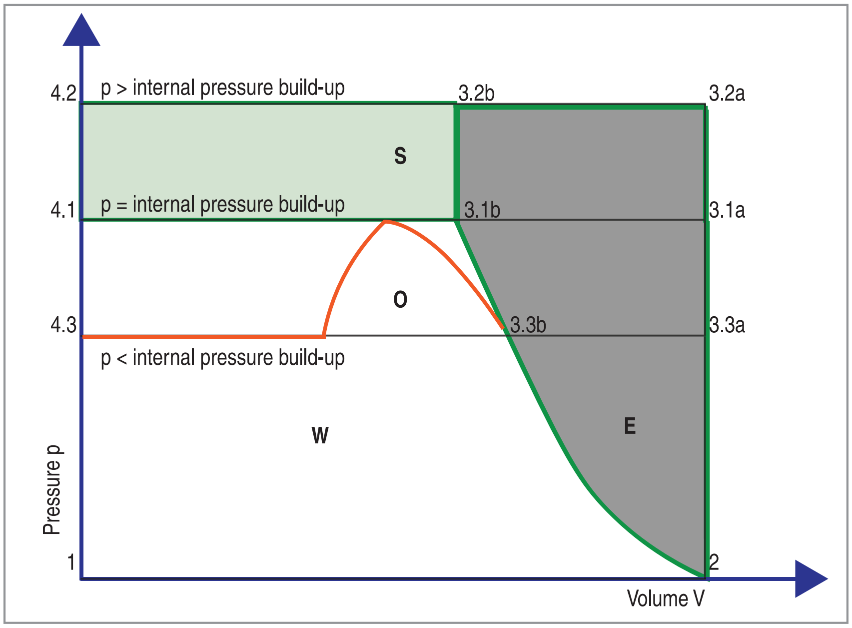

**DIAGRAM 3: CASE 2**

**Case 3 – Working pressure is lower than the internal pressure built up by the screw (Diagram 4)**

In this case, we will first examine the rotary lobe blower. Here, the rotary lobe blower conveys the air until pressure point 3.3a and discharges it after 4.3, adjusting to the lower pressure.

Conversely, the screw first builds up pressure internally to point 4.1. The pressure then falls as it dissipates to the lower working pressure. This over-compression is represented by area O (orange shaded area).

To ensure the work of over-compression is never greater than the potential savings, some manufacturers offer screw blowers with various internal volume ratios, which correspond to different magnitudes of internal pressure build-up. This makes it possible to select a model which produces the pressure closest to the required working pressure (minimizing area shaded in orange). Understanding the energy savings for a given application involves evaluating the ratio of actual load hours and idling hours (the time in which the blower works without system backpressure). In idle, the screw however continues to build up pressure internally which will increase the area O while decreasing area E.

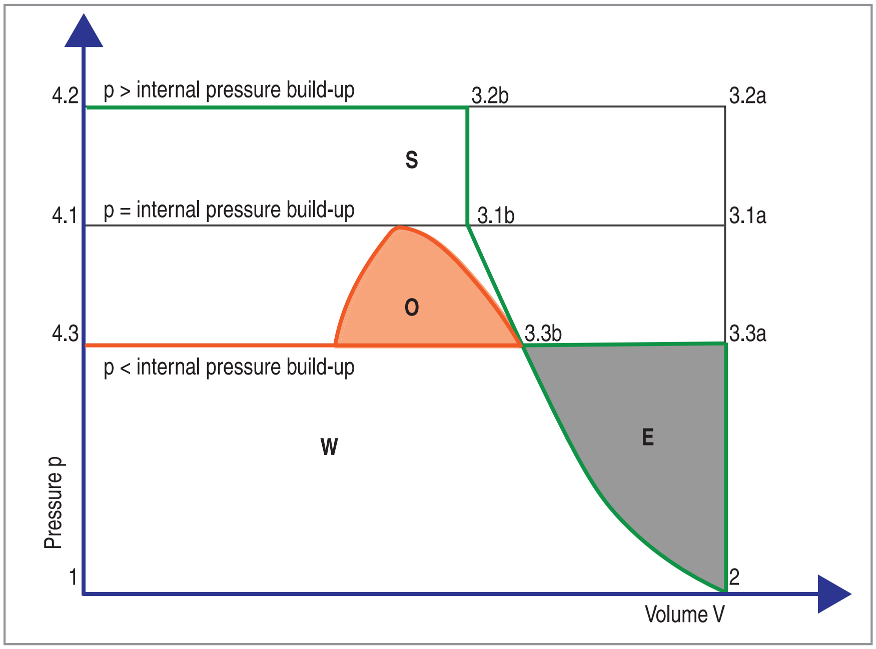

**DIAGRAM 4: Case 3**

# Example

**Case A**

Constant pressure over time, e.g. air introduced into a wastewater treatment pool with constant water depth. No idling, i.e. blower operation without back pressure.

**Case B**

Operation alternates between pressure and idling, operating without back pressure for some periods of time. This use case is common in pneumatic conveying.

## Table comparison

*With a pressure difference of 7.25 psig, i.e. 23 psia working pressure, compression ratio of 1.5:*

| Case | A | B |
|---|---|---|
| Idling Ratio | 0% | 50% |
| Rotary Blower | 140,800 kWh | 90,800 kWh |
| Screw Blower | 125,600 kWh | 103,200 kWh |
| Savings with Screw Blower | 11% | -14% |

*With a pressure difference of 14.5 psig, i.e. 29.2 psia working pressure, compression ratio of 2.0:*

| Case | A | B |
|---|---|---|
| Idling Ratio | 0% | 50% |
| Rotary Blower | 254,400 kWh | 147,600 kWh |
| Screw Blower | 188,800 kWh | 134,800 kWh |
| Savings with Screw Blower | 26% | -8.7% |

*It is evident from the above examples that the potential cost savings from using screw blowers increases with higher pressures and longer load times.*

Inlet pressure 14.7 psia, flow rate 530 cfm, 8000 hours per year service life, different load and idling ratios.

## Conclusion

Before creating an energy balance sheet, the required flow rate and working pressure should be known for every application – either drawn from historical data or based on prognoses.

On the other hand, a robust energy cost balance sheet is needed to calculate the amortization period of a screw blower, which usually requires a larger initial investment. For applications with significant proportions of partial-load or idling, this balance sheet must take into account the duration and energy consumption of these off load periods. The electrical work or energy consumption is therefore calculated as the sum of (output x load time) and (output x idling time).

If the load points are associated with different pressures and flow rates, it is well worth the effort to calculate the electrical work at as many of these points as possible in order to increase the precision of the energy balance sheet – enabling early detection of partial-loads that must be adjusted for.

It should also be ensured that realistic working pressures are used in the energy balance sheet, not peak pressures occurring only sporadically as a result of inflated safety margins. In the most unfavorable case, failure to do so could result in selecting a machine with excessive internal pressure build-up, resulting in unnecessary over-compression (area O).

Advances in technology provide opportunities to improve operations, reduce costs, and increase reliability. Before implementing changes, however, it is important to understand the specific purpose of the new technology and how it was intended to be used and applied. In the case of rotary screw blowers, it is clear that their efficiency and savings, while certainly desirable, are only achievable when properly applied. By calculating the necessary design parameters in advance, end-users can better understand what costs and savings they can expect when applying the technology to their application.

## About the Author

***Stephen Horne*** *is the US Product Manager for KAESER's blower product line. He has over 10 years of experience with the design and function of blower systems in wastewater aeration applications. Stephen has also served as KAESER's in-house engineer for machine modifications and system design. He is a primary blower product and application instructor in KAESER's Factory Certified Training program. Stephen holds a Bachelor's degree in Mechanical Engineering from Virginia Polytechnical Institute and State University.*

## About the Author

***Marcus Jungkunst*** *is the Product Manager Turbo-Blowers at KAESER KOMPRESSOREN in Coburg, Germany. He has over 20 years of experience in blower systems and the water treatment industry. He is influential in the design and development of KAESER equipment as well as calculation tools for the sales team. Marcus holds a degree in Mechanical Engineering with a focus in physical chemistry.*

KAESER
COMPRESSORS ®

***Built for a lifetime.***

**Kaeser Compressors, Inc.**
511 Sigma Drive
Fredericksburg, VA 22408 USA
Telephone: 540-898-5500
Toll Free: 800-777-7873
[us.kaeser.com](https://us.kaeser.com)
info.usa@kaeser.com

LGA InterCert
Certified
QM/EM System
DIN EN ISO 9001:2015/
14001:2015

MEMBER OF
CAGI
Compressed Air & Gas Institute

ENERGY STAR
PARTNER

*USWPBLWRTECH*