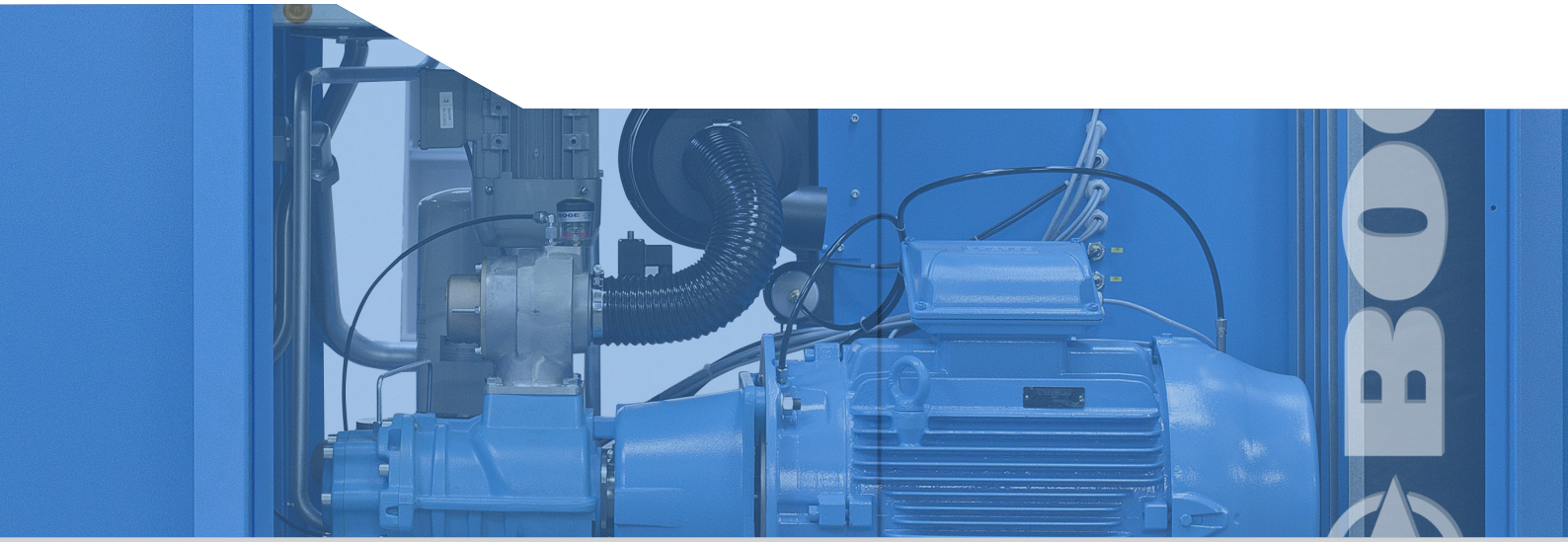
BOGE COMPRESSED AIR SYSTEMS

Understanding Variable Speed Compressors



Variable speed drives can be an effective way to reduce compressor energy consumption, but capturing the full benefits of the approach requires considerable care in equipment sizing, specification and operation.

Compressed air is an energy-intensive resource. As users seek to reduce their electricity bills, and their CO2 footprints, one increasingly popular option is the use of a variable speed drive (VSD) to control compressor operation. In principle, VSD control offers significant efficiency advantages. In many production facilities, demand for compressed air varies during the course of the day. A fixed speed compressor installation compensates for this variability by switching to an unloaded condition, or turning off entirely, when pressure in the system exceeds that needed to meet current demand. That can be an expensive mode of operation: an unloaded compressor will still consume energy even though it is producing no air, while repeated starts are also associated with spikes in energy consumption. With a VSD in place, the compressor will continually adjust its operating speed to keep system pressure within a set band, matching energy consumption much more precisely with demand.

If they are badly designed or incorrectly set up, however, VSD systems may offer little or no energy consumption advantage, can adversely affect system reliability and can even lead to the early failure of expensive system components. In this article we will look at some key considerations to help users maximise the benefits of their investment in VSD compressors, while avoiding the pitfalls.

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System sizing

A VSD installation can't compensate for a compressor that is improperly sized for its loads. If the loads are high relative to the output of the compressor, requiring to operate at more than 80 per cent of its capacity, then the savings achieved through variable speed operation will be minimal or non-existent. If a fixed speed compressor is already providing satisfactory operation in these conditions, it is likely that load variability is low, and the fixed speed device is the best one for the job. If demand regularly exceeds the capacity of the existing compressor, leading to a loss of system pressure, a larger unit is probably required.

Equally, VSD installations will perform poorly if demand is far below the capacity of the compressor for much of the time. Operating a compressor at very low speeds creates a number of potential problems, including motor overheating and excessive internal loses. As a result, compressor manufacturers set a minimum turn-down speed for their variable speed machines, typically 30 per cent of their maximum output. If demand falls below this threshold, the machine will revert to stop-start operation. In addition, the operating efficiency of many compressor designs falls away at lower speeds, so even if the machine can run slowly, the energy savings achieved may be very small. The low temperatures that result from extended operation at low speeds can also allow excessive moisture to build up in the compressor lubricant, adversely affecting reliability.

If the demand placed on a compressor is always much lower than its rated capacity, a smaller machine may be a better solution. In a more common situation, the installation may see long periods of low demand interspersed with infrequent peaks. Here it may be better to consider the installation of two compressors, one sized to meet base demand, the other providing the capacity needed at peak times. Either or both of these units may be fitted with a VSD.

Compressed air users can get a picture of the way demand varies in the installation by installing data logging equipment on their existing compressors and monitoring them for a representative period (typically one or two weeks). For a planned new installation, likely demand can be calculated using data from the manufacturers of the equipment that will use the compressed air, combined with the expected duty cycles of that equipment.

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System configuration

The performance of even a properly sized and specified VSD compressor depends upon the characteristics of the overall installation. One key consideration is the sizing of air storage. If storage tanks are too small, changes in demand will quickly alter the overall pressure in the system, making it harder for the compressor to maintain the required pressure, and potentially giving rise to more frequent starts and stops. Similarly, leaks and pressure differentials across pipework, filters and other system components can mean that pressure at the point of use falls below the specified range, especially during periods of peak use. The installation of remote pressure sensors close to the point of demand can allow the system to compensate for these issues without requiring excessive pressure at the compressor when it is not required.

The control parameters programmed into the VSD can also affect overall system performance. Most VSD compressors have a target pressure setting, upper and lower acceptable pressure limits and separate limits that determine whether the compressor should be unloaded or shut down if it reaches its minimum variable operating speed.

The system will behave differently depending on how these parameters are set. For example, if the target pressure is close to the upper limit, the compressor will run faster after start up, reaching the required pressure more quickly to meet demand peaks, but potentially consuming more energy in the process. Setting the target close the lower limit has the opposite effect, but can mean more frequent stops and starts during periods of low demand. The width of the acceptable pressure band will also affect the frequency of stops and starts, although this may be determined by the specification of the load.

Finally, the VSD controller will use a PID (proportional-integral-differential) control algorithm to match motor speed with demand. The PID parameters are usually set by the compressor manufacturer, based on their knowledge of the performance of the machine in normal operating conditions. Since the characteristics of each user's compressed air installation are different, it may be useful to tune these parameters, for example to reduce incidents of pressure overshooting or taking a long time to reach its target. Compressor manufacturers can provide assistance where this is required.

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Retro fit risks

Rather than buying a new variable speed compressor, some users may choose to retrofit a VSD to an existing fixed speed machine. This can be a cost effective way to improve the energy efficiency of their installations, but the approach is not without its risks. For example, to extend the speed range of their dedicated variable speed compressors, manufacturers typically fit them with a larger motor than used on fixed speed machines of the same capacity.

The bigger motor helps to cope with the issue of motor cooling at low speeds, allowing the manufacturer to extend speed range of the compressor. In a retrofit installation with a smaller motor, users may have to accept a higher minimum speed to prevent the compressor overheating and shutting down.

In addition, the high frequency switching used in variable speed drive can result in stray currents that pass through the motor bearings. Dedicated variable speed compressors use motors equipped with special insulated bearings. In fixed speed machines with standard bearings those currents can damage the bearing surfaces, leading to premature failure.

Finally, any retrofit VSD installation requires an appropriate control algorithm and parameters to ensure optimal machine performance. Manufactures ensure that the programs used in their variable speed compressors are designed to suit the characteristics of their machines, and they extensively test those programs to ensure they perform well in a wide variety of conditions. A VSD from a third party supplier may not be able to make such a claim.

VSD in application

BOGE variable speed drive compressors are helping businesses to cut their energy usage – and, in turn, reduce their energy bills. Our customer, Forbo Flooring, for example, recently installed our C15F 11kW variable speed compressor, in place of an old 18.5kW machine.

The new unit automatically adjusts to the air demand while controlling the pressure perfectly. The air end operates at the necessary speed to generate as much compressed air as is required, which means expensive idling as well as load/no load cycles are eliminated.

Just by employing a smaller variable speed compressor, Forbo Flooring is saving around £2,500 annually in energy costs alone. The company was so pleased with the installation that it plans to replace a second 18.5kW compressor, which currently acts as a back-up, with another BOGE VSD in due course.

A VSD compressor can provide significant energy savings in many compressed air installations, but only if it is designed and configured to suit the characteristics of the system and its loads. VSD is not a panacea, however, any company seeking efficiency improvements should consider the use of variable speed compressors alongside a range of other possible efficiency measures, including heat recovery, leak detection and improvements to air distribution pipework.

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