Compressed

Variable speed ac drives can shave a whopping 30% off fan and pump energy costs. Steve Ruddell makes the case for VSDs on compressors

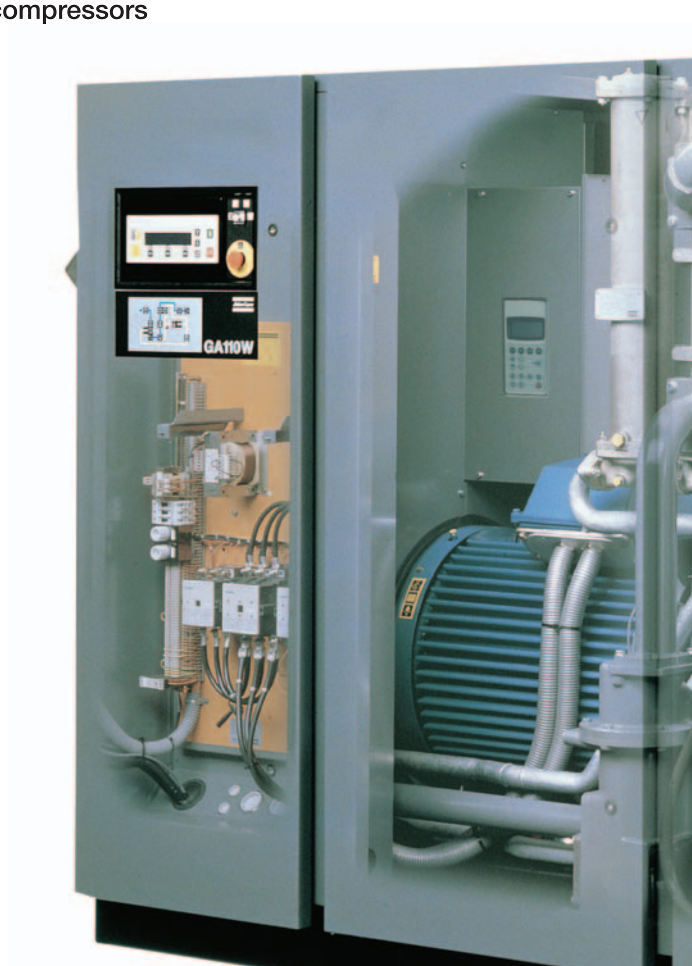
Technical pointers

- Variable speed drives can make a massive difference, compared with fixed speed stop-start
- Given the different types of compressors – positive displacement and dynamic – applying VSD is not as easy as on fans
- Positive displacement (reciprocating and rotary screw) are designed to increase pressure with driven speed, so VSD control yields savings under any load condition
- Life is less simple with centrifugal compressors, which follow the same affinity laws as pumps and fans, so have limited operational range
- Check for motor, lubrication and seal system suitability first

Electric motors use two-thirds of all electricity consumed by industry, so any technology capable of cutting this drain on resources has got to be a good thing. Yet, despite proven and significant savings from variable speed drives (VSDs) – particularly on fan and pump control duties – they are still installed only on a tiny minority of applications.

That's almost certainly because original equipment designers aren't responsible for running costs – so go for lowest plant cost only – or engineers specifying replacements just don't believe the benefits. If we're to make a real dent in running costs and do our bit for the environment, this has to change. And not just in fan and pump motor controls, but also air compressors, which typically account for one fifth of a factory's electricity bill and 10–12% of all power generated in the UK.

Just as with fans and pumps, savings result from managing compressor motor speed – ensuring they run no faster than required to deliver the target pressure. Compare that to the conventionally wasteful practice of fixed-speed start/stop operation, with air storage and/or bypass systems



and (more often than not) undersized motors that have been short-term rated, because they only pull high current on start-up.

So which types of compressors can benefit most from VSDs? There are two basic air compressor designs – positive displacement and dynamic – and the differences do make applying VSDs on compressors slightly more challenging than simply bolting inverters onto pumps or fans.

Looking first at positive displacement compressors, there are two types: reciprocating and rotary-screw. Reciprocating devices use pistons driven by a crankshaft. They can be static or portable, single- or multi-staged, and driven by electric motors or internal combustion engines. Discharge pressures range from low to very high (greater than 35MPa). In air compression, multi-stage double-acting compressors are the most

Benefits of VSDs

Variable speed drives work by controlling the waveform of both current and voltage supplying a motor. They convert incoming ac power to dc and then back to quasi-sinusoidal ac, using an inverter switching circuit. As a result, movement of the motor shaft can be accurately controlled.

Benefits include energy savings of 5–35%, with lower consumption at partial loads, because compressed air production exactly follows demand. Additionally, precise control allows lower discharge pressures, leading to additional savings (for example, just reducing system pressure from 7 to 6 bar cuts energy consumption by 7%).

Furthermore, cutting net pressure results in some 10% indirect saving, due to lower system pressure and fewer leaks. Also, VSD control brings improved process control, because pressure is stable, independent of air consumption and reacts quickly to demand changes, typically within 0.1bar. And there's the issue of less mechanical stress on plant, while smooth starting means no power surge penalties.

So why don't more plant engineers use VSDs? Many believe that traditional control methods are easier to implement and/or that the cost of wasted energy is less than that of buying a VSD. Not true: the energy savings are so significant that paybacks are sometimes less than 12 months. And, thereafter, the application continues to make a real cost-saving contribution.

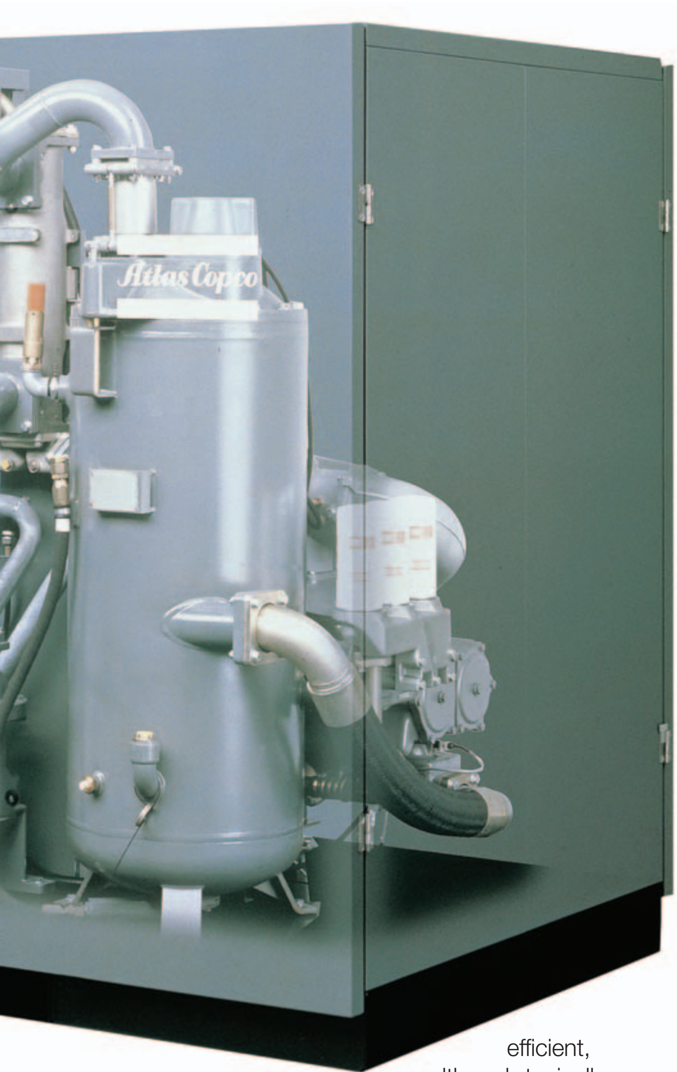
A professional air audit is the best way to see if variable speed drive compressors are right for you. VSD manufacturers, such as ABB, also offer full energy appraisals, systematically seeking out and quantifying plant for greatest energy savings. It is not unusual for users to dismiss the promise of 50% saving on a 20% speed reduction as mere exaggerated claims – but it happens.

energy

VSD compressors in action

Despite VSD-controlled compressors being relatively new, several installations have been successfully trialled. In Belgium, for example, a 275kW fixed-speed compressor was converted to 315kW variable speed. During tests with three different load profiles, savings between 18 and 25% were reported, resulting in an electricity bill reduction of more than €15,200 per annum, and providing payback in three years.

Meanwhile, a European biochemical company that needed oxygen at constant pressure, but very variable volume, moved from a conventional dual compressor (different sizes) on/off arrangement to VSD on its larger compressor. The result: energy saving of 1,700,000kWh/year, CO_2 emissions down 850,000 kg/year, and noise and maintenance reduced.



efficient, although typically larger, noisier and more costly than rotary units.

Meanwhile, rotary screw compressors use two meshed rotating helical screws. These units are typically used for continuous operation in commercial and industrial applications and, again, may be static or portable. Ranges are from 2kW to 375kW and they can handle from low to very high pressure (8.3MPa and above).

Both types can increase pressure, whatever the driven speed – so mechanical volume controls, such as inlet guide vanes, aren't necessary. Capacity can be managed directly by motor speed. Beyond that, energy consumption is directly proportional to speed and, unlike centrifugal compressors (see later), there are no limitations on speed range – especially where lubrication and cooling are not hazardous. As a result, applying VSD control with these compressors yields energy savings under any load conditions.

Dynamic compressors

Moving on to dynamic compressors, most plant engineers will be familiar with centrifugal types. These use a rotating disk or impeller in a shaped housing to force gas to the rim – increasing the gas velocity, which is then converted to pressure energy in a diffuser. These compressors are primarily used for continuous, static service in, for example, oil refineries, chemical and petrochemical plants, and natural gas processing plants. Sizes range from 75kW to thousands of kW and, with multiple staging, they achieve output pressures of 69MPa.

Typically, capacity control on these compressors is achieved by modulating inlet guide vanes, which adjust the air mass flow in line with load requirements. If motor speed control is used instead, since centrifugal compressors follow the same affinity laws as centrifugal fans and pumps, speed reduction will also reduce the compressor's capability to generate pressure. That means we're introducing a limit to the operational range that can be achieved through motor speed variation alone.

Nevertheless, remarkable savings can be achieved, because power requirements vary with speed cubed – so a small increase in speed requires a lot more power, while a modest speed reduction gives significant savings. Indeed, a compressor running at half speed consumes only one eighth of the power at full speed. So, plainly, applying VSDs to centrifugal compressors (specifically without removing the inlet vanes) brings worthwhile energy savings. How much depends on the difference between required pressure and the capacity of the compressor at its fixed speed.

Generally, however, plant engineers need to ensure that, whatever the compressor, it is suitable for variable speed operation, before installing VSD controls. You should also check minimum speed for the lubrication system and seals – although this does not normally present problems. PE

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