Not just hot

With the announcement late last year that Atlas Copco compressors can now recover 100% of their energy input, Peter Lattaway provides in-depth insight into the technology

Pointers

- Compressed air systems should be subject to a full audit for energy saving
- That fact is often overlooked, for reasons ranging from apathy to perceived cost of change
- Modern compressors, with intercoolers and water jackets, offer massive energy recovery potential
- TÜV Institute says that Atlas Copco's latest machine offers 100% electrical energy recovery
- Typical usage could save 165 tonnes of CO_2, plus £35,000 in energy costs

Prudent plant managers would no doubt agree that, to maximise energy efficiency, all areas of a compressed air system should be analysed to determine their true potential to reduce energy usage. That would entail a top-to-toe investigation of air generation, control and management, air treatment, air net design and leak detection, point of use delivery, as well as service and maintenance schedules.

But, surprisingly, a major factor in this endeavour that is frequently overlooked, ignored or simply rejected is the provision of an energy recovery system. That is in spite of the staggering statistics around industrial compressed air system energy consumption being common knowledge. Also, most plant engineers know full well that, as a rule of thumb, at least 85% of the energy used in a typical water-cooled compressor can be recovered as hot water.

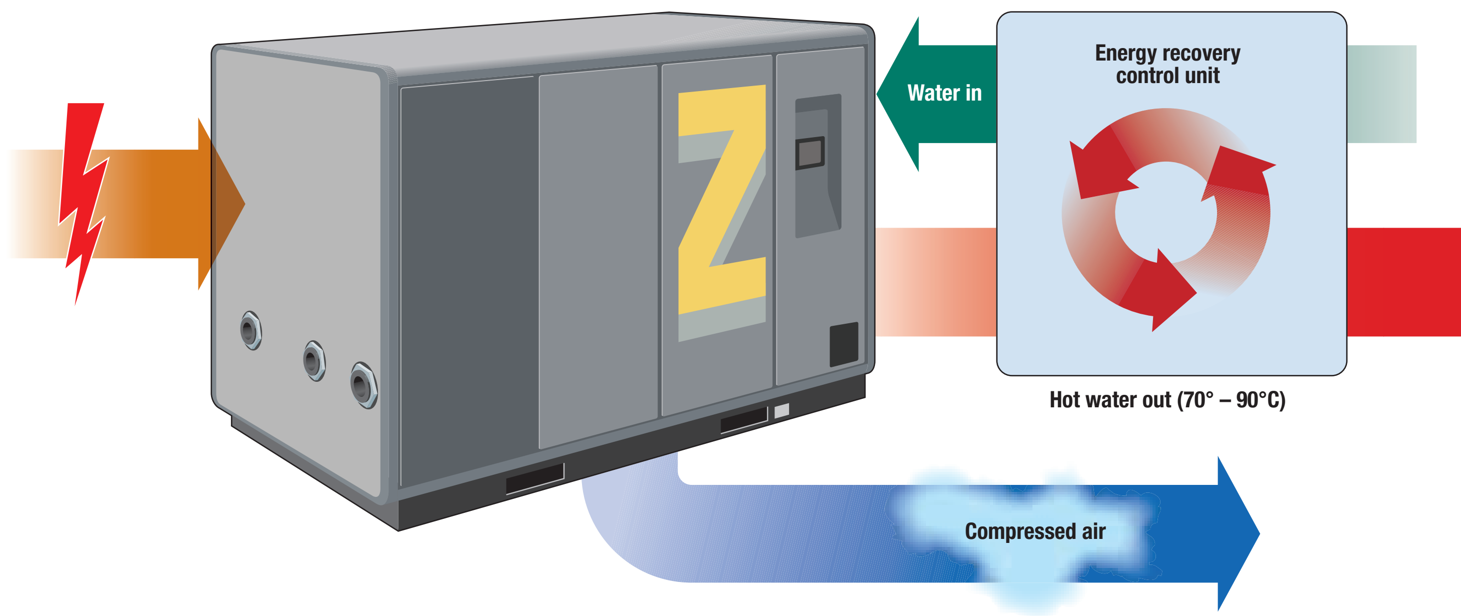
There may be a variety of reasons for this state of affairs. It could be due to a too-narrow focus on application requirements. Alternatively, maybe energy recovery is rejected, because of the perceived complexity of installing plant and integrating it with, say, an existing manufacturing process. And also it may be that, because of the age of an existing compressor installation, it is considered that the cost of retrofitting a recovery system could not be justified.

However, the facts remain that all compressors generate heat and many industries could benefit from recovering that heat energy, at least in the form of hot water. And, with the advent of Atlas Copco's latest compressor range – which last year was certified by the independent TÜV Institute as enabling heat recovery equivalent to the full amount of electrical energy supplied to the compressor – surely the time has now come to reconsider the energy recovery issue?

Energy losses

In theory, all energy used to compress air is lost as heat. A small amount of this heat energy is then lost from the compressor package through radiation, and there are other small energy losses through auxiliary components. Ambient air also contains moisture and, in the compression and cooling process, this condenses and releases condensation heat, or latent heat. When the latent heat cancels the other losses, the recovered energy, in the form of hot water, can be equivalent to the electrical input energy.

And, in a nutshell, that's how Atlas Copco's 'carbon zero' ZR 55-750 compressors (rated from



air

55 to 750kW) work. They are all two-stage, oil-free, water-cooled units, with an intercooler between the first and second compressor stages, plus an after-cooler and an oil cooler for the gearbox oil. In addition, both of the compressor stages have water jackets that also extract heat from the air, as it is compressed.

As with all compressors, ambient air input to the compressor contains moisture, which is condensed in the compression and cooling process. That releases latent heat energy, which is then recovered by transfer to the cooling water, resulting in the compressor generating both compressed air and hot water.

Energy savings

In tests on a ZR 55, using 121 litres per second of ambient air at 40°C and 70% RH (relative humidity), the compressor consumed 63.75kW of electrical energy. However, energy recovery (in the form of hot water flow) was 65.57kW, made up of 57.67kW of energy recovery without the latent heat and 7.9kW due to the latent heat. The level of energy recovery at other ambient conditions differs slightly, but Atlas Copco's tests demonstrate typically at least 90% electrical input energy recovery.

What does that mean? For a 10bar version of the ZR 55, with a free air delivery of 121 litres per second, the nominal flow of hot water is 0.24 litres per second. Not only could this save 165 tonnes of CO_2 per year, but it could also shave £34,192 off electricity or £35,500 from heating oil costs every year. Those figures assume that the compressor runs for 8,500 hours per year, and that current energy costs and typical boiler efficiencies pertain.

TÜV Institute supervised the tests and certified the compressors as the first in the world to be capable of providing for 'net zero energy consumption' at specific conditions. The official conclusion was: "100% of the electrical energy consumed could be recovered and net power [energy] consumption of the ZR compressor with built-in energy recovery at specific design conditions is zero."

There is clearly ample evidence that energy savings in compressed air production benefit plant operators' bottom line and the planet as a whole. The challenge ahead is the need to inform and educate compressed air users about the substantial rewards of utilising carbon zero technology and the need to integrate it within their manufacturing systems. PE

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Carbon zero compressors: how they work in practice

Heat from the air compression process is generated and transferred to the cooling water through the compressor's internal components. At 10bar (145 psig) and with inlet water at 20°C, transferred recoverable heat contribution is 12% from the oil cooler, 9% from the high pressure and low pressure compressor elements, 37% from the intercooler and 42% from the after-cooler. The result: 100% heat recovery in the form of water at 90°C.

General applications for this hot water output can easily be found in areas such as showers or washroom duties. But it is in those applications where hot water or steam is an inherent part of the production process that the biggest energy-saving opportunities occur. It should also be noted that air-borne heat recovery is easily achieved and this can be used for applications such as space heating.

Carbon zero compressors have been made possible by a combination of advances in high efficiency components and heat exchangers, the optimisation of oil-free compression element design and, as a further energy-saving feature, the integration of variable speed drive technology.

To illustrate the financial savings and environmental contribution, a typical carbon zero compressor application might involve a 132kW compressor with a heat equivalent of 132 kJ/second, running for 8,000 hours per year.

In addition to the main duty of supplying compressed air, its hot water output can be utilised as pre-heated feed water to an oil-fired boiler, thus saving boiler fuel. The following calculations are based on a boiler efficiency of 90%, the calorific value of heating oil at 41,200 kJ/litre and a fuel cost of 45p/litre.

- Heating oil saved = 132 x 3,600 / (41,200 x 0.9) = 13 litres per hour
- Heating oil saved over the course of a year = 104,000 litres
- Cost of fuel = £0.45/l x 13 l/h = £5.85 per hour
- Yearly savings = £5.85 x 8,000 hours per year = £46,800 per year
- Equivalent CO_2 = 104,000 x 2.518 kg CO_2 per litre † = 261,872 kg or 262 tonnes of CO_2

This carbon saving is approximately equivalent to taking 87 average cars off the road. *

† Energy conversion factor taken from Carbon Trust's Food Industry Factsheet CTL018: Energy and Carbon Conversions

* Based on the carbon emissions of 3 tonnes of CO_2 per year for an average car, with average annual mileage