Zero waste?

In Europe, 10% of electricity consumed by industry is for compressed air, yet much of that energy is wasted. In a carbon-conscious era, something has to change, says Steed Webzell

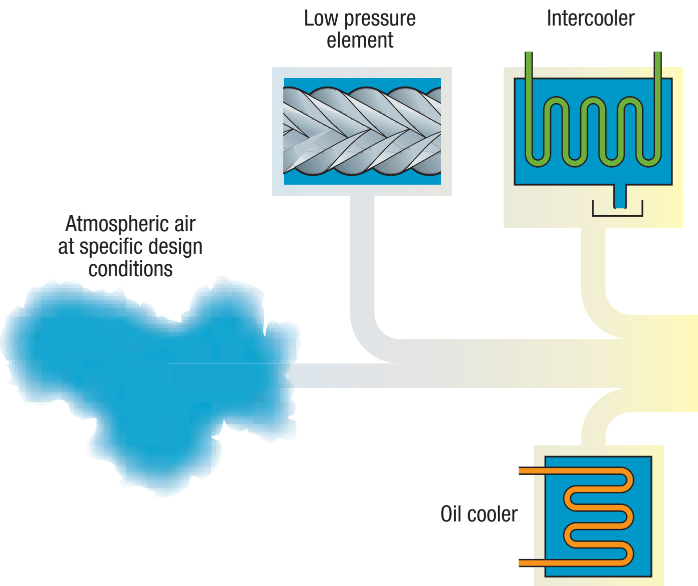
David Burton, Boge Compressors: heat recovery can now be ultra-efficient

It's a staggering statistic and yet one that passes frequently under the radar: 10% of all electricity consumed by industry in Europe is used to produce compressed air. That equates to 80 terawatt (10^{12}) hours per year. No wonder pressure has never been higher to reduce energy usage – and from both environmental and economic perspectives. And no wonder demand for new and innovative compressors is soaring.

Experts in compressor technology have approached the problem in different ways. David Burton, general manager of Boge Compressors, says that compressed air users can optimise energy usage through heat recovery. "In an oil lubricated screw compressor, approximately 4% of the heat remains in the compressed air as residual heat while 2% is lost to atmosphere through radiation," he says. "Importantly, 94% is available for heat recovery, which can be used to heat workshops or warehouse space, or even to heat water."

To determine the potential for energy and cost savings from implementing a heat recovery system, plant engineers must first assess heat demand in the area surrounding the compressor. This assessment should be compared to the average operating hours of the compressed air system, which will then demonstrate possible payback in terms of fuel, oil and gas cost reductions.

Boge has developed a standard heat recovery system for oil injected screw compressors called Duotherm – a heat exchanger that operates independently from the cooling system and can be installed directly into the compressor oil circuit.



According to the company, it can recover up to 75% of the electrical power used in the compressor.

Interestingly, Atlas Copco, which is also exploring this area, recently introduced what it claims to be the first air compressors in the world capable of net zero energy consumption (Plant Engineer, September/October 2009, page 4). These are oil-free screw machines and recover heat in the form of hot water at up to 90°C from an intercooler, after-cooler and oil cooler arrangement.

Total energy recovery

Earlier this year, TÜV (the independent German Technische Überwachungs-Verein institute) supervised type-testing of Atlas Copco's ZR 55-750 compressors, equipped with built-in energy recovery systems. Testing involved real-time measurement of the electrical power input and output hot water – and proved that, under specific design conditions of 40°C and 70% relative humidity, an amazing 100% of the input electrical power could be recovered.

Most sites can make use of hot water for space heating, showers etc. However, industries that will benefit most are those that have a continuous need for hot water and steam. Typical winners would include food and milk processing plants (scalding, cleaning, sterilisation and melting), pulp and paper plants (digesters and evaporators, and bleaching

Revolution in energy storage

Third generation compressed air energy storage is getting ready to solve a problem in renewable energy production. It could act as large-scale storage for electricity, produced from renewables in a fluctuating and decentralised way, and feed it into the network when needed – with less dependence on geographical conditions than hydro-pumped storage power plants.

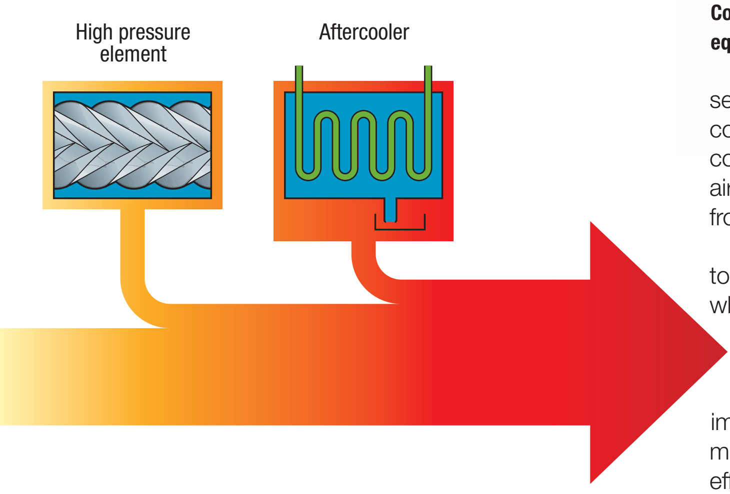
In compressed air energy storage power plants, ambient air is compressed and stored under pressure in a salt dome. When energy is needed, the store can release air, which is then used to drive a turbine to generate electricity and distribute it to the grid.

The latest development in this concept is to store the heat produced during air compression and use this for air pre-heating during release. This adiabatic process is exactly the approach being used by a consortium from GE Energy Infrastructure and RWE Power to develop an advanced, third generation compressed air energy storage with significantly higher efficiency (70%). Construction of a demonstration power plant is planned for 2012.

Compressors
equipped for heat recovery

and pulping plant), textile plants (dyeing and stabilisation of man-made fibres), pharmaceutical plants (fermentation and sterilisation), refineries, chemical and petrochemical plants (steam distillation, enhanced recovery, stripping, heat tracing) and power plants (electricity generation).

Meanwhile, the problems of moisture in compressed air, and the resulting inefficiencies, are well documented. As a consequence, modern compressors tend to be fitted with integral



refrigerant dryers. However, by their very nature, drying processes can be energy intensive, and this has led a number of compressor designers to rethink their drying equipment and processes.

A case in point is Atlas Copco's ID95-285 integral refrigerant dryer, used across a selection of its oil-injected screw compressors range. Here, energy savings and reductions in global warming potential of 40% and 50% respectively have been achieved, by introducing R410A refrigerant and by redesigning key components – such as the compressor and heat exchanger – for low pressure drop. The company's auto-regulation algorithm also enables the dryer's start/stop cycle to be based on the dryer load and ambient temperature, which reduces power requirement. The air-to-air heat exchanger also reduces energy consumption, while preventing corrosion damage from condensation forming on the outside of the pipework.

In a similar vein, the latest Arctic Energy range of compressed-air refrigerant dryers from Hi Line also claims to achieve a minimum energy profile. During normal operation, incoming warm, wet pressurised air from the compressor passes through an air-to-air heat exchanger within the dryer, where it is pre-cooled by the already processed outgoing cold, dry air. This helps reduce the load on the dryer compressor and, again, saves energy.

The compressed air supply then passes through an air-to-refrigerant heat exchanger that further cools the air to a pre-set dew point. Where this is set at 2°C, moisture in the processed air condenses into water droplets. In the final stage, the cool, dry processed air is then returned through the air-to-air heat exchanger, where it picks up heat from the incoming pre-processed air stream.

The bottom line: for plant engineers, it is essential to ask questions of a current system to identify where improvements can be made. Has the demand profile been mapped? Are the compressors the right combination of sizes? Has energy use been benchmarked, so that the impacts of any changes can be validated? Are multiple compressors being controlled by an effective management system?

Finally, EnergAir is one organisation that has made identifying savings relatively simple, with a free online compressed air energy savings estimator at www.energair.com. This provides users with an accurate estimate of potential savings, both cost and kW. It's worth looking: lower carbon emissions resulting from energy efficient equipment may qualify purchasers for a Carbon Trust interest-free loan. PE

Mortar site cements savings

A compressed air audit conducted on a dry silo mortar (DSM) production site in Scotland has revealed that 56.07% of the input energy used was non-productive. The cause: an inefficient, but very common, cascade control system, originally installed to manage three 75kW fixed-speed Atlas Copco compressors. The audit also highlighted that using three compressors of the same capacity did not allow the system to match air output to demand.

The solution adopted was to install an EnergAir Metacentre compressed air management system, retrofit a variable speed drive on one of the existing compressors and change the line-up to include one smaller 30kW compressor. Offload energy usage was reduced by more than 90%, while additional operating efficiencies led to total energy savings of 61% or 182,728kW/h.

EnergAir specialist Peter Tomlins makes the point that many plants still use fixed speed compressors, operating on cascaded pressure switch control. While this is frequently seen as the norm, it is massively inefficient, he says. Why? Because the precise requirement of compressed air invariably falls between the combined capacities of the installed compressors — yet, as one compressor's limit is reached, the output doubles as the next compressor comes online.

Now, with the Metacentre management system taking data from pressure sensors on the air ring main, demand is continually assessed in real time, and the system selects the most efficient combination of compressors and compressor speed to match that demand – also keeping air pressure at the required 6.0 bar, a useful reduction from the previous 7.5 bar. By the way, it also provides plant condition updates every few seconds, to help maintenance engineers identify faults and reduce the risk of running compromised compressor plant for many hours.