Waste heat recovery market warms to ORC

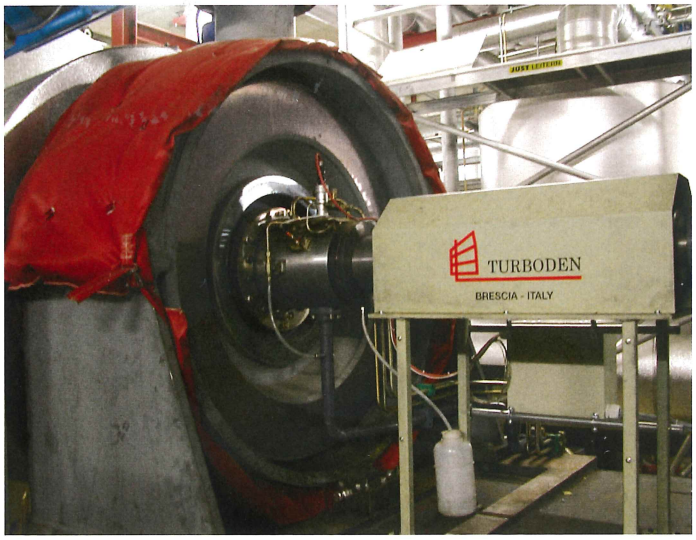
Coming somewhere between piston engines and gas and steam turbines in terms of typical output, and with significant reliability, flexibility and process efficiency benefits, Organic Rankine Cycle technology looks poised to secure a growing proportion of the industrial waste heat recovery business in the coming years. **David Appleyard**

According to recent market research from Global Market Insights Inc, the worldwide waste heat to power market will be worth more US$30 billion by 2024. With energy intensive industries like metal and glass production obvious applications, Germany alone is expected to see around 800 MW of waste heat to power installations over the next six years. The metals sector is predicted to experience 12% growth in waste heat recovery deployment by 2024, while industries like chemicals, oil and gas and cement are also expected to benefit significantly from installing waste heat recovery systems.

One technology that is increasingly being considered in waste heat recovery applications is the Organic Rankine Cycle (ORC) turbine. Using a high molecular mass organic fluid instead of steam, the characteristics of the fluid result in relatively low rotational turbine speeds and pressures. Turbine inlet pressures are of the order of 10-20 bar. Typically, the turbine is connected directly to the generator without the need for a gearbox, with a speed of 1500 or 3000 rpm, for example. Working fluids include oils, ammonia and standard commercial refrigerants like R134.

ORCs can use a wide variety of fuels or low temperature heat sources, down to around 110-120°C. Such heat sources include not only waste heat from industrial processes but also biomass, geothermal and energy from waste facilities. Although low temperatures mean overall efficiency is relatively low – 20-25% total cycle efficiency – ORCs are flexible, and highly suitable for part-load operations. When power is reduced to 50% of maximum output, ORC efficiency is expected to drop by only around 2%. Although the lower peak efficiency does make for a longer return on investment period, say 6-8 years in a typical application, there are nonetheless considerable environmental and commercial benefits associated with ORC in waste heat recovery applications.

Furthermore, based on a closed loop cycle, ORCs don't use steam and so are suitable for locations where water is scarce, and also don't suffer from the corrosion and wear issues associated with steam. In addition, the lower rotational speeds and reduced pressures lessen mechanical wear in bearings and in areas such as blade tip seals – leading to low maintenance requirements and long operational lifespan, with availabilities of 98% and more for some manufacturers.



Turboden Organic Rankine Cycle turbine installation

ORC turbines have outputs typically in the range of 500 kW to 30 MW, placing the technology, in capacity terms, between large steam or gas turbines, at the higher output end, and standard reciprocating engines, at the lower end of the output range.

As a result, microgrid and islanded power applications are also suitable for ORC technology along with applications like mechanical drive.

ORC turbine manufacturers include ABB, GE, Ormat and Exergy. Italian firm Turboden is also a leading supplier of ORC technology. Founded in 1980 by Dr Mario Gaia, the company's first commercial project was in Switzerland in 1998, following a decade of R&D. By 2009 more than 100 Turboden units were in operation and unit outputs had reached 1 MW. In 2013 a majority stake in the company was acquired by Japan's Mitsubishi Heavy Industries (MHI) and today, well over 300 units have been installed, with a combined capacity of more than 570 MWe.

ORC units from Turboden are sold packaged and typically feature remote monitoring capabilities as their small size often makes the provision of an on-site operations control room uneconomic.

The Turboden ORC turbine features a relatively compact axial turbine with a rotor diameter of around 1.5 m and between one and six stages.

European geothermal energy is another area that is expected to see growth in ORC use. For example, in 2016 Turboden supplied a 16 MWe five-stage axial machine for a geothermal project in Croatia. Installed at Velika Ciglena by Geoen – MB Holding, the machine uses steam and hot water at 170°C as the heat source.

However, the market is currently led by heat recovery applications. For example, French glass-production company Saint-Gobain recently signed two heat recovery deals with Turboden: one for the supply of a 1.2 MWe unit in India and another for a 1.2 MWe installation in Italy, which will produce both electricity and compressed air. August also saw SACE SIMEST, the export and internationalisation hub of the CDP Group, ink a €4.4 million deal for a Turboden installation destined for Turkey's glass industry while a 6.2 MWe unit is being commissioned at the Düzcecam glass plant, also in Turkey. "The Turkish market is currently…offering new business opportunities," noted Violante Moretti, CFO of Turboden.

Looking ahead, Turboden is currently planning to roll out a new venture focused on both steam and power delivery for applications in process industries that have significant demand for steam but lower power requirements.

This puts ORC in a contrasting role to reciprocating engines, which tend to supply more power and less heat for steam production. The lower efficiency of ORC is less of a disadvantage in such applications, where demand for steam equates to about 75-80% of the total energy output.

ORCs in waste heat applications commonly use an intermediate heat transfer fluid that carries energy to the working fluid via a heat exchanger. Turboden is also currently developing higher temperature working fluids, suitable for temperatures up to 400°C, making it possible to dispense with the intermediate fluid stage, reducing costs and complexity.