A waste heat recovery solution

Sabrina Santarossa* discusses how Organic Rankine Technology is a particularly effective technology solution for waste heat recovery and can help glass manufacturers meet the sustainability challenges they are facing.

Glass factories are undergoing sustainability improvement especially in terms of energy efficiency.

Process optimisation and energy efficiency to reduce emissions are more important then ever for all glass producers. Nevertheless still today, 30-35% of the energy input in glass production is lost in the off-gas. This waste is an economic loss and it can be leveraged using proven technologies, such as Organic Rankine Cycle (ORC), to benefit glass producers and the environment.

In the last 10 years Turboden, in the frame of environmental sustainability, has proposed and installed successfully several Waste Heat Recovery (WHR) systems, based on ORC technology, to recover the thermal power available in the waste gas at furnace's outlet and valorise it producing electricity or compressed air.

WHR working principle

Heat contained in the exhaust gas is typically transferred through heat recovery exchangers directly or indirectly (typically using thermal oil as intermediate fluid) to the organic fluid inside the ORC plant.

In the ORC, the organic fluid is heated and vaporised in the pre-heater and evaporator thanks to the external heat source (gas or thermal oil). Organic vapour expands into the turbine producing mechanical power that can be transformed into electricity through an electric generator or used to drive a compressor thus producing compressed air. After the expansion in the turbine, organic vapour is firstly cooled in the regenerator and then condensed in the condenser. Once again in the liquid form, the organic fluid is pumped into the regenerator and then in the pre-heater,

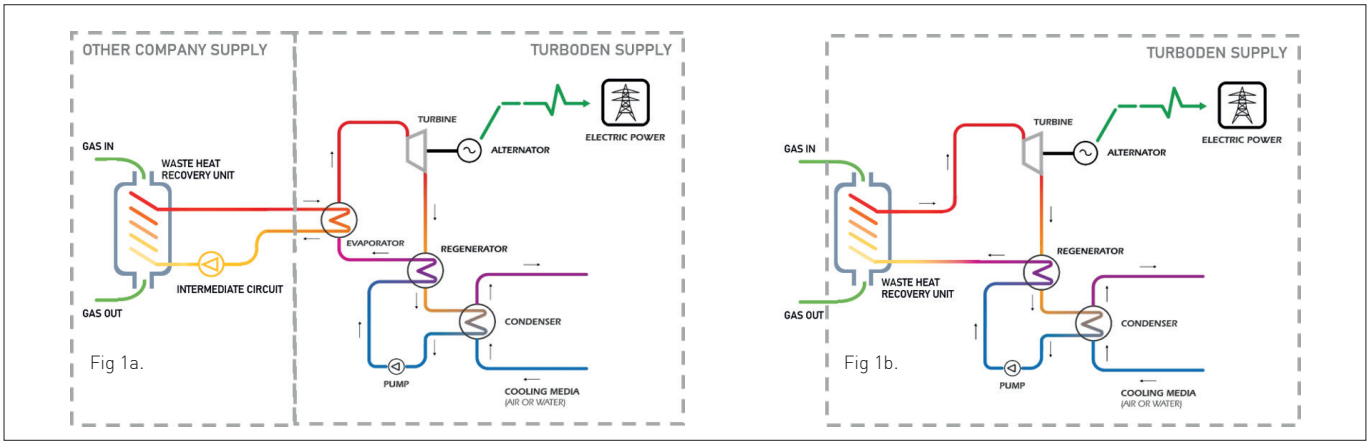
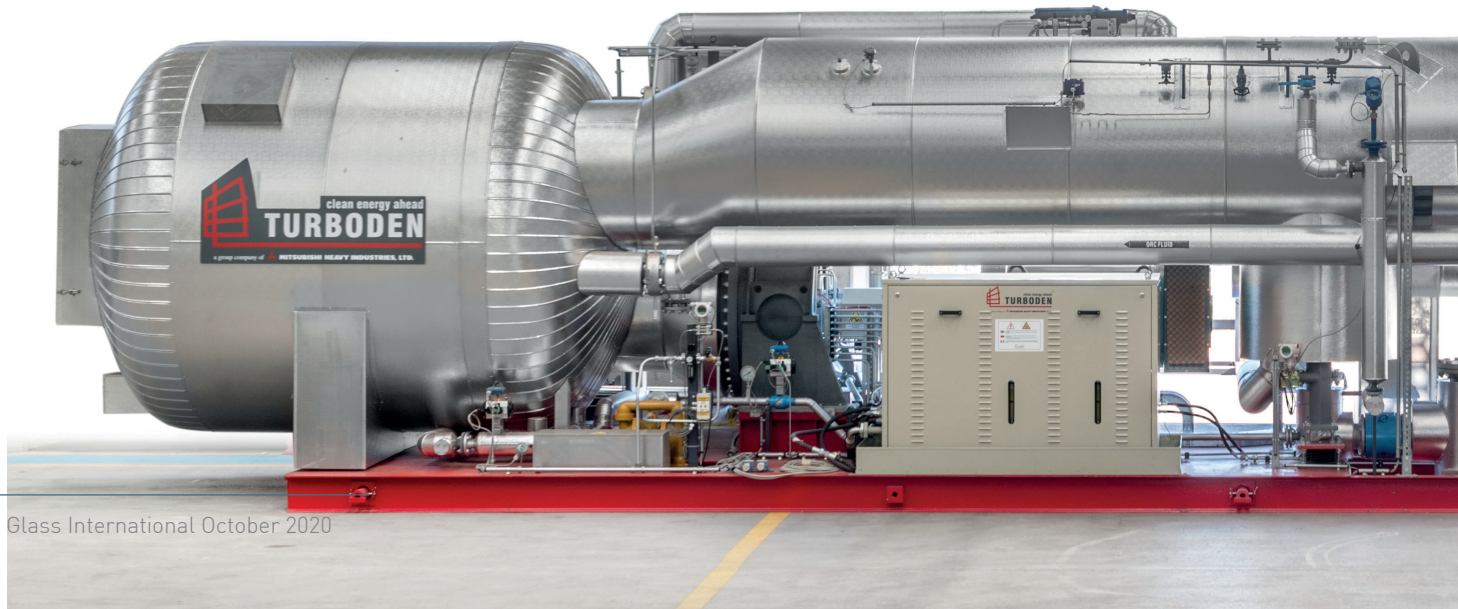


Fig 1a.

Fig 1b.



thus closing the thermodynamic cycle.

Recovering the heat from a float glass 600 t/day furnace leads to an electric power of 1.2 – 2.4 MWe, while in the typical size container glass plant the possible power production is in the range of 0.5-1.5 MWe depending on furnace numbers and size.

Summarising, there are two ways to recover heat from the glass production process exhaust gas: directly and indirectly and there are two possible use of turbine mechanical power: electricity production or compressed air production widely used in container glass process.

Direct exchange versus Indirect exchange

The direct and indirect schemes of WHR solution are shown in ***Figs 1a and 1b***.

On a direct exchange configuration, the main advantage is the lower investment cost because there are less components (no thermal oil circuit).

The solution is more compact and the net power output is higher since there is no thermal oil pump.

Direct exchange solution is suitable for single heat source (e.g. heat recovery after the filtration system).

Turboden has designed a standardised solution for power output in the range 400-800 kW and it is possible to optimise the solution with few adjustments based on exhaust gas characteristics.

On the other hand, indirect scheme is suitable when multiple heat sources (e.g. multiple gas lines, heat recovery before and after the filtration system) and gives advantages of layout flexibility and easier regulation in case of variable heat source. This scheme is used for medium-large plants (above 1 MW).

Power produced through WHR, not only electricity

Turbine mechanical power can be exploited to producing electricity and/or compressed air.

The compressed air, needed in the process, could be produced by a compressor driven by turbine shaft.

In such way global efficiency rises since generator and motor efficiency are avoided and 100% of mechanical power is transformed in compressed air. Other advantages are related to the easier authorisation process (no grid connection needed).

Hybrid solutions are also possible and are already in operation in Saint-Gobain Italy. In this case the turbine is connected to a double shaft generator that is connected to the compressor. About half of mechanical power (500 kW) is transformed into electricity, while the rest is used to produced 80 Nm^3/min at 7 bar(g) (***Fig 2)***.

ORC technology

ORC is a mature technology commercially available since the '70s, originally for geothermal energy exploitation and more recently – since the '80s and '90s – also for power production from biomass combustion, solar and heat recovery from industrial processes.

Turboden has more than 40 years of experience in the ORC field and several steps ahead have been taken to improve the technology. Today, there are currently about 370 Turboden ORC plants in operation and further 30 plants are under construction. The average availability of the operating fleet exceeds 98% and more than 15.000.000 operating hours have been reached.

Several benefits of ORC technology:

- No negative impact on industrial process: WHR plant is installed in by pass to the main gas duct.
- Completely automatic system: self-regulating operations with no need of supervision personnel.
- Increase sustainability of the process and contributing to decarbonisation goal given to the industry.
- Decrease energy cost: production of electricity exploiting exhaust gas heat wasted into the atmosphere. Increase of competitive advantage while reducing energy cost guaranteeing a low Levelized Cost Of Electricity (LCOE) for the whole WHR life.
- Possible configuration with no water consumption.
- High availability, higher than 98% on a statistical basis.
- Minimum maintenance requirements and cost during the whole life of the plant (more than 25 years)

With regard to the heat recovery from glass production process, several are the successful references projects deployed:

- AGC Cuneo plant. A 1.3 MWe Turboden ORC unit has worked since 2012. In 2018 the glass furnace was rebuilt and no modification to the existing WHR were needed.

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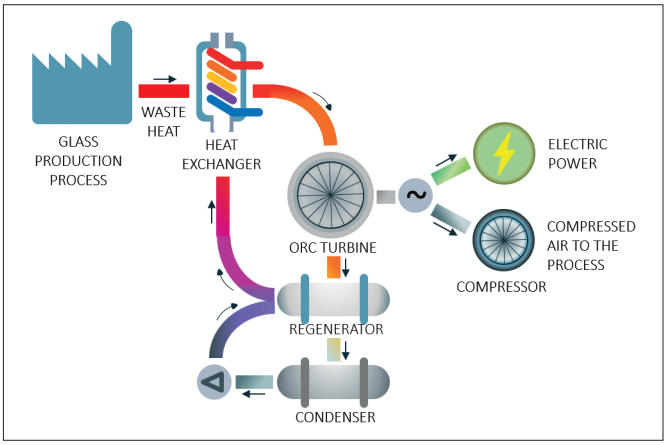
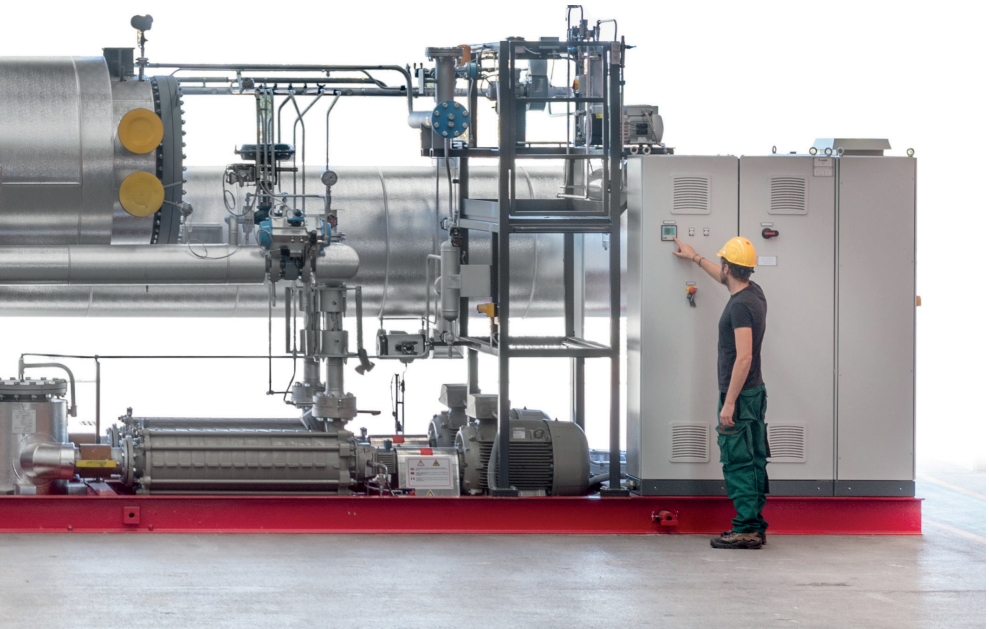


Fig 2 Hybrid solutions are already available.

Fig 1 a and b (far left). Direct and indirect schemes of Waste Heat Recovery solution.

Pics 1 and 2 below Turboden ORC generator.



- Container glass in Italy. A 0.5 MWe ORC started up in 2015.
- Duzce Cam – Duzce plant, Turkey. A 6 MWe ORC unit is working since 2018.
- Saint-Gobain Chennai plant, India – a 1.2 MWe ORC unit started up in 2019.
- Saint-Gobain Pisa plant, Italy – a 1 MW hybrid (electric power plus compressed air) ORC unit started up.

From an economical point of view WHR feasibility is driven by energy cost, local incentives and initial CapEx.

Glass furnace works for 8760 hrs/year thus helping in decreasing payback time. Bigger WHR plants have a lower specific cost, while for small ORC direct exchange solution can be the best solution to decrease specific cost.

Conclusion

Sustainability of glass process is becoming more and more important for glass industries. On this regard WHR is one option that better exploits available energy actually wasted allowing to decrease also energy cost.

The ORC technology - thanks to its ability to recover heat at medium low temperatures, together with good electrical efficiency, high flexibility and minimum operation and maintenance cost– is the ideal technological solution for effective and profitable implementation of systems of heat recovery in glass processes.

Finally, there is a continuous commitment in finding new technical solutions with the aim to improve economical results of WHR plants. ■

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