Waste heat recovery expertise

The industrial production of glass is energy-intensive and is subjected to a number of constraints imposed by European directives, including those relating to greenhouse gas emissions. Italy, a country poor in energy resources but at the same time historically linked to innovation in the production of glass, provides critical engineering for the industry. Daniele Forni reports.

Improving production efficiency not only enhances financial performance but also reduces emissions and improves the product's LCA. There are several possible efficiency measures, including the recovery of heat from flue gases leaving the furnace. Otherwise, these flue gases are dispersed downstream of the recuperator/regenerator [1, 2].

The temperature of the outlet gas from the furnace is around 400ºC-500ºC for installations equipped with regenerative heat exchangers, or even higher for systems with recuperative heat exchangers. Installing an additional heat exchanger can recover heat at temperatures around 300ºC or higher. The recovered heat can be exploited for internal thermal uses (eg preheating raw materials and/or fuel, generating process steam or for auxiliary systems, heating rooms) or usually for external thermal uses with further investments (eg other industrial users in medium and low temperature or district heating/cooling) if there are users nearby (figure 1). If there are no other uses for the recovered heat, it should be considered to generate electricity, usually consumed within the plant itself.

From a financial standpoint, the additional heat exchanger to the furnace recuperator/regenerator is >

Figure 1: Possible uses and priorities in the recovery of waste/dispersed heat.

Figure 2: Organic Rankine cycle turbogenerator of the AGC Cuneo plant.

Figure 3: Flue gas treatment and heat exchangers at the Sangalli Manfredonia plant.

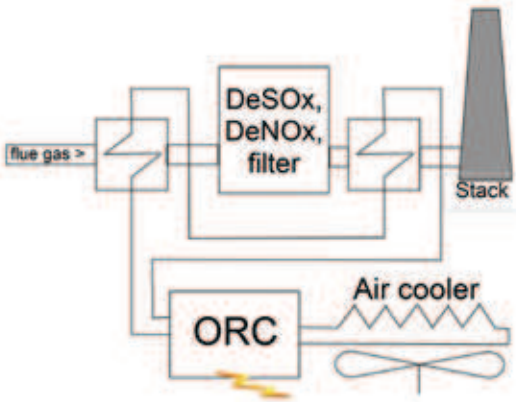

Figure 4: Heat recovery for electricity generation with two heat exchangers, before and after flue gas treatment.

Range	Capacity [t/day]	ORC Power [kW]	No. Plants	Total ORC power [MW]
<400	350	1 040	1	1.0
400-550	475	1 040	22	22.9
550-700	625	1 500	28	42.0
>700	750	1 800	7	12.6
Total			58	78.5

Table 1: Evaluation of the potential of ORC installations in the EU27 flat glass industry.

the main component to enable the recovery of heat. It is also the most expensive component in a heat recovery system to generate electricity. All installations of flat glass in Germany and several in Europe are equipped with waste heat boilers [1].

Typically, the additional heat exchanger is located before the plant flue gas treatment, so there is no need to lower the temperature - up to that supported by the filter - diluting the flue gas with external air or spraying water (quenching tower).

POWER GENERATION SOLUTION

The temperature and the amount of heat recoverable for a single production line are often not particularly high. This usually limits the use of recovered heat for power generation with steam turbines, at least not employing other fuels to ensure the steam does not overheat.

The organic Rankine cycle (ORC) is an attractive solution to generate electricity from waste heat, even for low power and discontinuous flows of hot gases with temperatures around 300ºC or even lower. The ORC has a lower sensitivity to temperature and flow rate changes of hot gases, affording greater management simplicity, whereby the presence of specialist personnel is not required. It has lower operating costs, does not need water treatment or consume water. The characteristics of the organic fluid permit operation even outside design conditions without the risk of ruining the turbine blades (there is no possibility of condensing in the turbine) or heavily penalising the yield [3].

Italy currently boasts the only two examples of ORC in the international glass sector, thanks to certain boundary conditions; the electricity price (€80-90/MWh) and an effective incentive mechanism, the white certification system [4], recognising for the first five years of operation around €60/MWh for the electricity produced. Taking into account the incentive, economic evaluations indicate a discounted payback period of less than four years [3].

The first ORC was installed at the Sangalli glass plant in Manfredonia and has been fully operational since the beginning of 2011. An installation at the AGC plant in Cuneo started electricity production in the first quarter of 2012. These two systems have been implemented by different contractors with different ORC turbogenerators - produced by ORMAT and Turboden (figure 2) respectively - heat exchangers etc.

Both plants produce flat glass and are equipped with recuperative furnaces with a rated production of approximately 600 tonnes/day. In the case of Cuneo, the thermal power recovered from the furnace flue gases before gas treatment allows some 1.3MW of electrical power to be generated. Conversely, the Manfredonia plant has two heat exchangers (figure 3), one before and one after gas treatment and a higher rated power of the ORC module (figure 4), which will reach a yield of around 2MW with glass production at full rate, progressively with the ageing of the furnace. Another peculiarity is that the ORC system in Manfredonia was installed and is maintained and operated by an Energy Service Company (ESCO), which funded the installation at its own expense.

The energy required to produce one tonne of glass is between 1 and 2MWh and around 30% is dispersed in the exhaust gases [1]. If half the energy is recovered, assuming an electricity conversion efficiency of 20%, it is possible to produce between 30 and 60kWh of electricity for every tonne of glass. It should be noted, however, that even when the system operates at reduced production, a condition that can occur in periods of severe crisis like the current one for two very important sectors for flat glass (construction and automotive), the ORC continues to produce electricity, only partially affecting the payback time and return on investment.

The application of recovery systems for the generation of electricity for hollow glass is also under consideration in Italy, feasibility studies having been prepared for several potential customers. The potential for this technology in the local flat and hollow glass sectors has been assessed as part of the European project HREII (Heat Recovery in Energy Intensive Industries). This involves 24 plants with an installable electrical capacity of around 23MW and a production of around 150GWh/year.

The HREII-demo project continues the HREII project at a European level, by promoting actions to support the recovery and exploitation of waste heat. It assessed a European potential limited to flat glass [4] of 58 systems, with a total capacity of around 80MW (table 1) and an annual electricity output between 400 and 600GWh, depending on the hours per year of operation of the plants. ■

REFERENCES

1. Best Available Techniques reference document for the manufacture of glass, JRC – European IPPC Bureau 2012.
2. Energy recovery from waste heat in the glass industry and thermo chemical recuperator, Hans van Limpt, 73rd Conference on Glass Problems 2012.
3. Heat recovery for electricity generation in industry, D Forni, N Rossetti, V Vaccari, M Baresi and D Di Santo, 2012 ECEEE Summer Industrial Studies.
4. White certificates for the industrial sector, D Di Santo, E Biele and D Forni, 2012 ECEEE Summer Industrial Studies.
5. ORC waste heat recovery in European energy-intensive industries, HREII-demo project, 2013.

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