As a service for the industry, TNO has investigated whether a new combination of proven technology can be applied in order to save energy, reduce production costs and decrease waste gas emissions. About 30% of the energy input is lost by the heat of the exhausted flue gas. Generating steam by flue gas heat, and using this steam to pre-heat cullet, will lead to energy savings between 8% - 12.5%.

The Netherlands based OPTIMUM Environmental & Energy Technologies has developed and successfully implemented an innovative waste heat boiler concept to utilize the enthalpy of flue gas as energy source for the production of steam. This system consists of a special designed fire-tube boiler with patented Automatic in-line Pipe Cleaning System (APCS).

Systems have been in operation since January 2007 in both flat glass and container glass production plants. Fouling is under control, resulting in no down-time for cleaning. Stable furnace operation is guaranteed without effects on furnace pressure stability. In most applications, the steam produced is used for building heating purposes or heating the high-viscous fuel-oil to become more fluid.
Recently, OPTIMUM presented a concept to use the generated steam for preheating and drying cullet and potentially pelletized batch.

**Feasibility study for container glass industry**

In 2010, the TNO Glass Group, OPTIMUM and a major container glass manufacturer carried out a system evaluation and economic-technical feasibility study for the application of the OPTIMUM steam driven cullet preheating concept for one of their furnaces. As an integral part, a system evaluation was also carried out for a typical 320 MT/day gas and 320 MT/day oxy fuel fired furnace to show the potential energy savings and cost savings. The furnace performance evaluation (energy consumption, flue gas flows, heat losses) with and without cullet preheating as well as setting up typical realistic cases is based on TNO’s extensive energy balance modeling capabilities and experiences.

For two cases (one regenerative, and one oxyfuel furnace), a relatively efficient new furnace was used as base case to ensure realistic savings calculations. This furnace type reflects modern glass production in Western Europe with cullet ratios between 65% - 85% for colored container glass, the cullet is preheated up to 210°C.

**Energy savings**

The energy efficiency improvement for both investigated furnaces varies from 8% - 12.5%. Based on the 2009, Eurostat average energy prices, energy cost savings fluctuate between € 440,000.- and € 650,000.- per year for a 320 MT/day pull regenerative furnace and € 720,000.- and € 784,000.- per year for a 320 MT/day pull oxy-fuel fired furnace (taking into account the cost savings for oxygen).

**Stabilization of cullet**

As a result of the preheating of the cullet, the quality of the cullet will increase and become stable.

**Increase pull**

Preheating the cullet as previously described enables the option for a significant pull increase of a glass furnace (pull increases of 5% - 10% seems to be possible for furnaces with cullet preheating and more than 75% cullet in the batch).

Cooling the flue gas in a steam boiler means that air type flue gas coolers frequently installed upstream bag house filter systems are no longer required. The required temperature window for specific type of abatement systems, like DeSO₂, SCR deNOₓ and an ESP (Electrostatic Precipitator) can be designed by a proper selection of the steam boiler.

The additional benefits where not taken into account in the energy savings calculations but it goes without saying that they could lead to a reduction of the return of investment of the project and significant improvements in glass color stability and oxidation state (redox). For most cases the return on the total investment would be less than 3 years.

**AGC Flat Glass: “The special designed fire tube boiler with the APCS systems results in an availability of the heat recovery system of 100% over the first operational year”**

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