Preheated oxygen and natural gas in flat glass furnaces

Antonella Contino* and Fabrice Fasilow discuss a breakthrough furnace technology that, from initial results, has substantially reduced melting energy as well as CO2, NOX and SOX emissions.

AGC Glass Europe has been focusing its manufacturing and R&D activities on lowering its energy consumption and greenhouse gas (GHG) emissions from flat glass furnaces.

These activities are divided into four levels: from state of the art, to disruptive technologies (***Fig. 1***).

The first step in reaching the best energy performance of flat glass furnaces can be defined as getting the best available know-how on state of the art technology.

To achieve this, efforts have been made to fundamentally understand all the physical phenomena linked to the melting of raw materials. This has been carried out by using CFD numerical simulation, analyses of energy audits performed on site, standardising best furnace design, and testing and spreading best equipment and practices among the float furnaces of the group.

Once the foundation for the 'best' furnace has been set, the second action is related to the correct monitoring of furnace parameters. The selection of the most adequate sensors is a key issue, to be able to characterise the process and further improve it. A third layer of actions is linked to the improved use of data collected from sensors by defining and applying a control loop to stabilise and adapt the process online. An investment from AGEU in those three categories of actions leads to a continuous energy efficiency and GHG emission improvement (***Fig. 2***).

Nevertheless, the trend of energy consumption over recent years has shown that without a major technological breakthrough improvements within classical furnaces (regenerative air combustion furnace) will remain limited. Action is required to improve and risks have to be taken by the industry to pursue the effort.

AGC Glass Europe has developed flat glass furnace technology (***Fig. 3***) that uses pure oxygen instead of air as an oxidiser, combined with the recovered energy from waste gases to preheat oxygen and natural gas. As 79% of nitrogen contained in air is useless for the combustion process and produces nitrogen oxides (NOx) at high temperature, it is known that the use of pure oxygen instead of air helps reduce the energy required for combustion and prevents the formation of NOx. Nevertheless, the application of oxy combustion is rare in the flat glass industry as its economical profitability is low and technical challenges are associated with it (e.g. foam, furnace corrosion).

AGC Glass Europe overcame the profitability issue by developing a system that re-uses heat from the flue gases to preheat oxygen and natural gas before it

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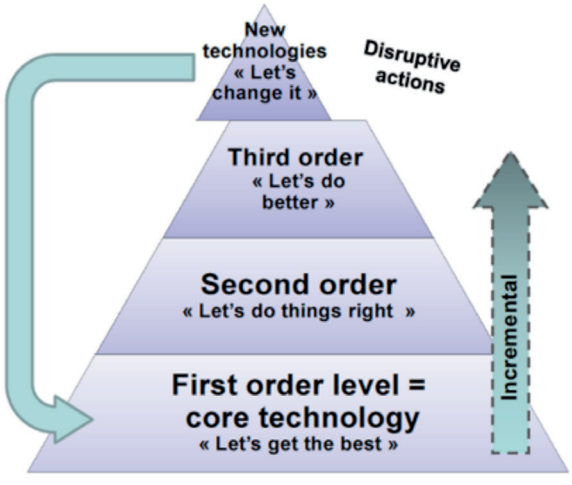


Fig. 1. Incremental development of energy saving actions.

Fig. 2. Specific energy required to melt 1 ton of glass (1880=100).

is injected into the furnace. This yields extra energy savings. The energy recovery system is a two-step methodology. First, hot waste gases (~1350°C) from the furnace combustion preheat air to around 700°C in a metallic recuperator. Later this preheated air will be, burner by burner, divided into two flows to preheat oxygen at 550°C and natural gas at 450°C in crosscurrent heat exchangers.

Regarding the technical challenges and risks, numerous studies have been carried out at both an R&D level (such as 3D numerical simulation; lab furnace tests) and on an industrial scale (conversion to new technology of one burner in a classical furnace), to try to decrease industrial uncertainties.

Industrial application

The final technical validation of this breakthrough technology could only be performed by taking a risk for a real industrial prototype start-up.

The first industrial application was located in Boussois, France, and started in 2008 (***Fig. 4***) with the aim at validating the feasibility of producing good quality architectural clear glass with a hybrid combustion, using partially heavy oil and partially natural gas.

During this first experience, AGC Glass Europe evaluated and validated technical items. These included technology design (furnace, burners, refractory); safety issues linked to hot oxygen use; glass melting settings (fire curve, atmosphere and foam management); and environmental and energy interests.

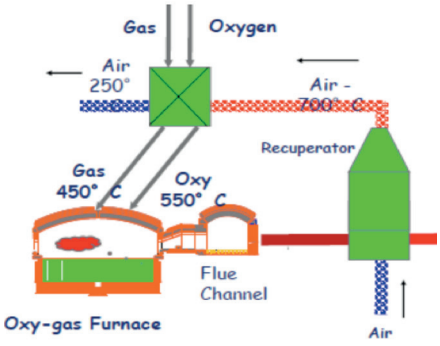
Valuable know how and experience were acquired on site to complete the preliminary studies carried out in a lab before a prototype start up. Unfortunately, the economic market situation led to production being halted at this furnace in 2013.

This first project was funded in part by the European Commission Environment-LIFE Programme-HotoxyGlass- LIFE07 ENV/F/179.

The second industrial application was located in the Czech Republic (***Fig. 5***). It was aimed at demonstrating the maturity and potential of the new technology by producing high quality automotive colour glass (which has higher quality requirements than architectural glass), using only natural gas as a combustible (more corrosive atmosphere; more foaming on glass surface).

This second application started in mid-2014 and is still under evaluation, but has promising initial results. The first glass from an oxy combustion furnace has been supplied to an automotive customer.

This project was also funded in part by the European Commission Environment-LIFE Programme-HOxyGas- LIFE11 ENV/CZ/488, for the implementation of preheated oxygen and gas combustion technology to produce high quality colour glass for the automotive industry, and by the European Commission SILC Programme- FHRS - for fumes heat recovery system implementation.



▲ Fig. 3: Oxy combustion furnace and heat recovery scheme.

▲ Fig. 5: The Czech Republic oxy-furnace.

▲ Fig. 4: A prototype of an air/fumes recuperator in France.

Benefits

Compared to 100% gas air combustion technology, which is a state of the art reference, this project should allow the furnace to decrease melting energy by 19.7%, reduce CO2 emissions by 5.5% (taken into account CO2 emitted by O2 production).

NOX emissions will be decreased by 79.2%, SOX emissions by 35.5% and dust emissions by 67.7%.

These prototypes serve as an example to the AGC Group as the most ecological flat glass furnaces in the world. The breakthrough technology that was developed is now being validated for the combustible and glass products market, thanks to the two industrial prototype furnace experiences.

It should be noted that the economical evaluation of the technology is closely linked to the energy price (both fossil fuels and electricity), and this can be a barrier to its deployment in some countries.

Environment

The technology described in this article is part of AGC Glass Europe's environmental policy. Environment is one of the four shared values of the AGC group and is an essential part of the company's Social Responsibility. AGC Glass Europe is taking its environmental responsibility seriously and turned this responsibility into a challenge: a challenge to achieve the best balance between sustainable development and economy, and to make improvements in terms of profitability, comfort and safety, aesthetics and environmental impact.

AGC Glass Europe's environmental policy has a double focus:

- To be at the forefront in developing new products with improved environmental performance during their lifetime.

- To manufacture these products using the best available technologies from an environmental point of view, to minimise the environmental impact. ■

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http://www.agc-glass.eu/

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