Auxiliary injection for NOx reduction

Auxiliary combustion is a patented technique for reducing NOx in end-fired and cross-fired regenerative furnaces. According to Richard Pont and Iain Shoveller, the technique has been shown to be capable of reducing NOx in typical glass melting furnaces to 500mg/m³ (at 8% O2) equivalent to reductions of 60%.

Traditionally, regenerative glass furnaces are fired with turbulent diffusion flame burners, located in or under the air ports. This causes initial rapid mixing of hot combustion air and fuel, resulting in high temperatures in the flame envelope generating high concentrations of NOx.

The principle of this development is auxiliary combustion, in which a second (auxiliary) fuel jet is introduced to the furnace in such a way that it mixes with the combustion products circulating within the furnace before mixing with combustion air. This produces an auxiliary flame free from the high peak temperatures of the conventional flames from under-port or through port burners, resulting in lower NOx.

Auxiliary combustion should not be confused with staged combustion, which involves injecting fuel into the path of the combustion air further along the combustion path from the primary burners, whereas the process being investigated here requires entrainment of combustion products into the fuel stream.

INDUSTRIAL TESTING
Funding provided by the EU FP7 programme allowed two commercial glassmakers to join the development, thus providing facilities for industrial testing of the process.

RESULTS
End-fired furnace tests: Although the three furnaces, Pilot, EF1 and EF2 were of different sizes and operated under different conditions, with different base case NOx levels varying from 600 to 1000mg/m³(88%O2), the reduction in NOx, relative to the amount of auxiliary injection was very similar, as shown in figure 1.

In all cases, the CO in the top of the regenerator chambers could be kept below 300ppm (less than 100ppm at the stack) and melting conditions maintained. No adverse effects were observed on the refractory and fuel consumption was unchanged within a +/-2% band of variability.

It should be noted that the relationship of percentage auxiliary injection to the NOx reduction is very similar, regardless of the furnace size, pull or initial NOx.

Cross-fired furnace tests: Tests over a period of a week on the 600 tonnes/day float glass furnace with auxiliary injection through the crown showed that operating with 20% and 40% auxiliary gas reduced the NOx by 20% and 30% respectively in the relevant port exhaust, with proportionate reduction in the stack. The proportion of AI was limited by problems caused by blocked regenerators on this old furnace. The result was similar to earlier pilot furnace trials and was very similar to the relationship found on end-fired furnaces. A summary of the results is shown in figure 2.

The trial indicated that the system can be installed and operated on an operating furnace without loss of production or glass quality. CO was less than 300 ppm in the regenerator top and less than 100ppm in the stack. The NOx reduction agrees with the predictions and there is no reason to believe that auxiliary injection up to 60% or more could not be achieved on a furnace not having regenerator blockage problems experienced on the trial furnace.

APPLICATION
End-fired furnaces: The most convenient location for installing the auxiliary injectors is the breast wall, using a water-cooled injector. As explained previously, the position and direction of the injector jet is critical. Usually, one injector per side is sufficient.

A typical mounting arrangement is shown in figure 3. The direction of the auxiliary gas jet is predetermined and set by the injector nozzle. Rotation of the injector provides vertical angle adjustment for final setting.

It is important to provide a correctly designed, reliable cooling water supply to ensure long life and
The investment and running costs of auxiliary injection are significantly less than alternative NOx reduction methods, capable of achieving similar NOx levels such as SCR.

CONCLUSION
The auxiliary injection technique has been shown to be capable of reducing NOx on both end-fired and cross-fired furnaces to levels below 500mg/m³, without compromising glass pull or quality. The equipment required is relatively simple and may be installed on-the-run if necessary. Location and direction of the injectors is critical and is dependent on the furnace design. Therefore, careful investigation is required before application.

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