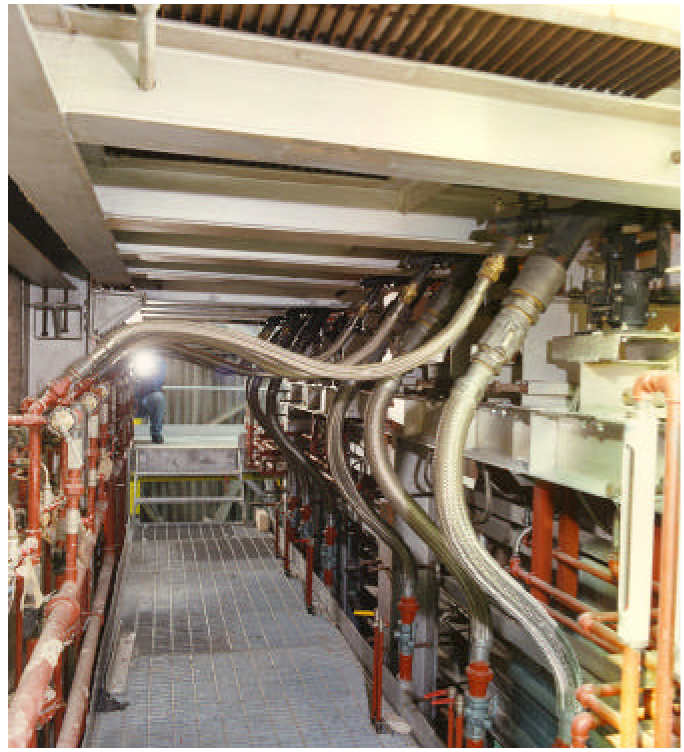
New generation of end-port furnaces



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The TECO Group had the opportunity to build two new end-port furnaces in 1994 and 1995. By coincidence, they were on sites a few hundred yards apart in Knottingley, West Yorkshire. The requirements were very different, but the end result was two very similar furnaces. The first contract to be won was for Gregg & Co., an old family firm which had recently come into the same ownership as Lax and Shaw in nearby Leeds, who decided to start a programme of modernisation. Their business is in flint containers, with the accent on relatively short runs. The second furnace was for Stolzle Flacconage, who operated on a site recently acquired from Rockware Glass, and whose business is in the cosmetic and toiletry sphere, calling for higher quality glass.

Hence the very different requirements, one for good quality glass and a relatively hard-pulled furnace, and the other with the accent on cosmetic quality at the expense of output, led to furnaces with a distinct family relationship, and of similar size.

Both were subject to the UK's recently introduced Environmental Protection Act, which laid down guidelines for the emissions of pollutants, and both made provision for retrofitting exhaust gas treatment plant, if experience of operation indicated that they were required to comply with the regulations. The permitted limits are shown in Table 1.

All concentrations are to be expressed at standard conditions of 273K and 101.3kPa without correction for water vapour content and normalised to 8% oxygen content measured dry. However, the local authority Environmental Health Office adopted the reasonable view that the furnaces should be allowed to begin operation on condition that an emission treatment plant would be installed, if necessary.

Furnace Specifications

TECO have consistently maintained that well-designed glass furnaces can deliver molten glass of high quality, with excellent fuel economy, without the need for unusual features, process aids and other gimmicks. Furthermore, that close control of melting conditions can minimise the discharge of some pollutants to the atmosphere.

The specification for Gregg's G-2 furnace reflected this philosophy. It was to have the best possible regeneration within the constraints of the site, so that energy usage would be less than 50 therms/tonne at rated output of 120 tonnes/day, with 15% cullet in the batch. Melting was to be by top-firing with natural gas, without the use of electric boost. Oil would be available as an alternative to the interruptible gas supply.

Table 1: UK Limits for Emissions from Soda-Lime Container Furnaces

Particulate Matter	100mg/Nm^3
Sulphur Oxides	750 mg/Nm^3 with gas firing, expressed as SO_2 1750 mg/Nm^3 with oil firing
Nitrogen Oxides	2700 mg/Nm^3 expressed as NO_2
Chlorides	50 mg/Nm^3 expressed as HCL
Fluorides	5mg/Nm^3 expressed as HF

The glass line was to be 4.8m above the machine floor level, and the main building structure was not to be disturbed. However, the backwall of the furnace house could be removed, and buildings behind it demolished, to make way for an extension of the building. A pit for regenerators and a cullet pit beneath the machines would be provided by Gregg & Co.

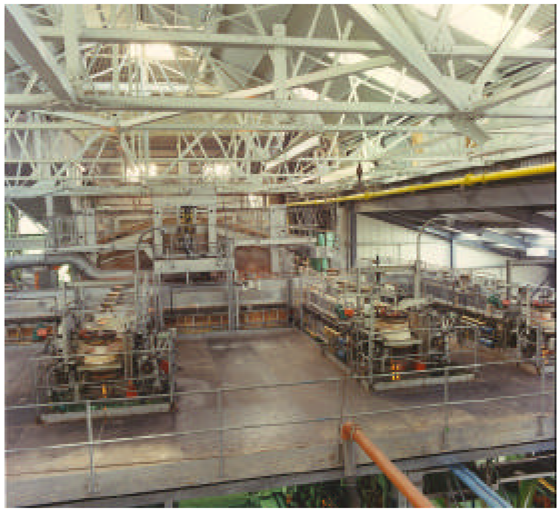
Exhaust to the atmosphere was to be by ejector stack rather than through the existing common chimney. Provision would have to be made for the future connection of pollution control equipment, in case it was not possible to achieve the levels of pollutions laid down in the Authorisation for the plant under the UK's Environmental Protection Act.

The second furnace, for Stolzle Flacconage Ltd., was installed in an existing building which had previously housed two end-port furnaces, and later an all-electric furnace for opal glass. A batch plant later occupied one corner of the building, and the forming machines were located on an intermediate floor, so that regenerators could be built from ground level up, instead of in a pit. This allowed a furnace very similar to, though not identical with, the Gregg's furnace to be provided, and was relatively free from dimensional restraints.

Stolzle's requirement was for high quality glass for cosmetic flint bottles, and so the furnace was much more lightly loaded. Provision was made for a hot-spot boost to be added in the future, so that the pull could be increased while maintaining quality. The regenerators had to be as good as was practicable in the space available, which allowed for a slightly taller checker pack than at Gregg's. Some changes were made to refractory selection in the interests of glass quality. In addition, the forehearth layout for this furnace dictated by the need to pick up drop points from existing and previous forehearths in this building.

A similar ejector stack was provided for the Stolzle furnace, modified to suit the changed duty, and again, with provision for the future connection of pollution control equipment.

TECO took care of a comprehensive package of work, including the new foundations and additional piling, while Stolzle were responsible for refurbishing the building and for equipment from the feeder bowls onwards. The resulting building and workspace is to a high standard, reflecting the value of the products made on the new production facility.



A new four shop container furnace installation recently installed in the United Kingdom

Furnace Description

The following description relates to the Gregg's G-2 Furnace. Except for slightly different dimensions, and the few changes to refractories mentioned above, the Stolzle furnace is essentially identical.

The furnace was designed on the basis of 48.0 M2 melting area. This allowed the furnace to be fitted into the available building width, with an extension of the building outside the existing back wall to accommodate the regenerators. A new pit, approximately 4m below the machine floor level, was excavated to allow the regenerators to be built, and a shallower basement continued beneath the furnace and machines.

The furnace is an end-port unit, with dual-fuel burners beneath each port. The burners are equipped with water-cooled sealed-in nozzles, and interchangeable gas or oil lances. Change-over between gas and oil is a very simple operation. The sealed-in design prevents the entry of parasitic air around the burner nozzles, and allows operation at very low excess air levels. This feature helps to reduce the generation of nitrogen oxides and provides more controllable combustion.

Batch is charged by the oscillating pusher-type of machine, with flood feed from a new batch hopper and rate of feed controlled by varying the pusher speed. The charger sits on a doghouse, designed to allow the batch to begin fritting before it enters the main melting chamber. This feature minimises the risk of dust pick-up from the batch and helps to reduce the loading of particulate matter in the exhaust gas.

The melter tank itself is a plain rectangle, with tilt-cast AZS sidewall blocks, insulated with composite insulation blocks. The doghouse corners are in void-free fusion-cast AZS, and are water-cooled on the outside. The bottom is paved with bonded AZS.

There is a sunken throat, with facers, cover blocks and stringers in void-free fusion-cast AZS. After the well-up, the glass contact material in the distributor and forehearth connections is fusion-cast alumina.

The melter breastwalls are a combination fusion-cast AZS, and silica at the bridgewall end. The doghouse cover arches outside the breastwall are in bonded AZS. The melter frontwall is in bonded AZS, while the backwall and the ports are in fusion-cast AZS. The crown is in silica. All (except the silica) are backed up with veneers of firebrick and insulating board. The silica crown is backed up with porous silica insulation with blanket.

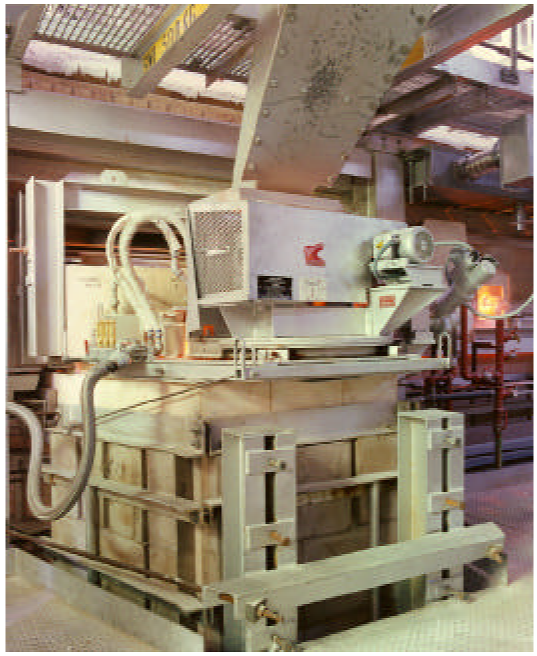
The port necks have AZS sidewalls, crowns, and paving on the bottoms.

The regenerator outer walls are a combination firebrick and andalusite. The division wall is a ventilated design. The crowns are in andalusite. Outside the insulation brick veneer is a sprayed-on coat of insulation. The checkers are chimney blocks. The chimney blocks were chosen over a conventional brick packing because of the added stability. This construction uses lessons learned from other high performance furnace designs, and will provide high levels of preheat with minimal maintenance. The high preheat reduces the amount of fuel required, and so the volume of exhaust gas is lower, leading to reduced quantities of emissions.

The flues lead to an ejector stack, and incorporate manually adjusted trimming valves to ensure that the ejector system of furnace pressure control is within range. The stack outlet is 35m above ground level, and the stack incorporates sampling points for the testing of emissions and for the continuous monitoring equipment. The monitoring systems include cross-stack measurement of particulates and measurement of N0, No_2, $S0_2$ and oxygen, thus allowing normalised concentrations at standard conditions to be reported.

A closed-circuit TV system is provided, with the camera in the melter frontwall. This has a 90° field of view, and allows the conditions within the melter to be visually monitored and recorded on a time-lapse video recorder. The camera lens is water-cooled and the camera itself is in an air-cooled enclosure. A pneumatic retraction system allows the camera to be withdrawn manually or automatically, and reinserted under manual control.

The instrumentation and control system for the furnace and forehearths represents the most up-to-date technology, with PLCs used for the control functions and PCs as the operator interfaces. There are two PLCs; one normally handles furnace control, and the other handles the distributor and forehearth control, but both can handle the entire system, if required. If one PLC should go off-line for any reason, there is a seamless transfer to the other. There is also a manual back-up system for all the main control loops, as a last result. Like the PLCs, the PCs (which act as operator interfaces) can also handle the entire system, and a "Windows for Workgroups" network can allow remote PCs to interrogate the system. Colour VDUs show graphic displays for each system and control loop, with an easy to use method of selection of the displays. A colour printer allows screen dumps to be made of the instantaneous situation, and historical data is easily retrieved, with trends and averages available in graphical form. The control loops include:



Charger/doghouse area of recently installed endport furnace

- Melter temperature control
- Glass level control
- Melter pressure control
- Melter reversal control
- Melter fuel-air ration control
- Melter gas flow control
- Melter oil flow control
- Combustion air mass flow control
- Distributor temperature control, with provisions for heating or cooling
- Forehearth temperature controls, with provisions for heating or cooling.

Temperature monitoring includes inputs from bottom thermocouples, crown thermocouples, regenerator crown thermocouples, and a stack thermocouple, fibre-optic infrared pyrometers in the distributor and similar pyrometers in the forehearths.

The distributor and forehearths were the modular type with special pressure control system and low forward velocity burner system, which allows start-up from cold with very high turn-down rations.

Operational Experience

Both furnaces were started up on the anticipated dates, and soon settled down to normal production.

In the case of the Gregg's furnace, the pull has been higher than originally specified, occasionally reaching 170 tonnes/day or more, with the normal level in the region of 135 tonnes/day. Energy consumption is comfortable below the originally requested level.

Frequent changes in production are normal, and so the furnace has to cope with a wide range of conditions, and is seldom in a stable long-term operating environment. Nevertheless, glass quality is good and the first stage of modernisation of this factory can be judged to have been successful. In addition, results so far indicate that stack emissions are within the UK limits and sulphur oxide emissions at about the limit, the level being dictated by the need to achieve an acceptable level of glass quality. Nitrogen oxide emissions have been found to be exceptionally low.

The Stolzle furnace has also been providing glass of excellent quality, to suit its designated market. Output is also above the specified level, typically reaching 90 tonnes/day, at which level the energy consumption is almost identical with that of the Gregg's furnace at the same pull.

As with the Gregg's furnace, the stack emissions appear to be consistently within the UK limits. Like the other furnace, nitrogen oxide levels in the exhaust are much lower than usually found with regenerative furnaces, with results in the region of 1,000 mg/Nm^3 of $N0_x$ being consistently observed.

Conclusions

A well-designed, no-frills furnace is capable of delivering energy consumptions which are comparable with the best in the industry for a similar unit, while keeping emissions down to the levels stipulated in the United Kingdom.

This is done without recourse to weir walls, deep refiners, bubblers, electric boost or oxygen enrichment, and with minimal changes to batch formulation.

The key features of the furnace are adequate insulation, good sealing to minimise air in-leakage, excellent heat recovery from efficient regenerators, a well-designed doghouse and charging system, a sunken throat and, not least important, a precise and accurate control system.