Forehearths of the future

The role of the forehearth in the glass forming process. By John McMinn.

There is a natural line of responsibility apportionment in all systems and cultures, which ultimately finds an unfortunate but inevitable end stop. In the glass industry this is the raw material supplier. The lehr manufacturer will blame the machine supplier who is quick to blame the forehearth supplier who is of course convinced the problem lies with the furnace designer, who rightly knows the problem is with the batch system supplier, who eventually gets round to the raw material supplier.

Apart from forewarning of the possible down side of supplying raw materials, this tongue in cheek story does have a more serious message. The glass forming process is not the sequential operation of several contiguous, discrete systems but is in fact a complex blend of processes each effecting the process it feeds. With the exception of cord dissipation, where stirrers are sometimes employed, the forehearth plays no role in chemical conditioning or refining of the glass nor does it contribute to the removal of bubble or seed from the glass. These functions are carried out exclusively in the furnace. Together with glass temperature and glass temperature stability, this effectively defines the minimum expectation of the furnace in terms of glass input to the forehearth.

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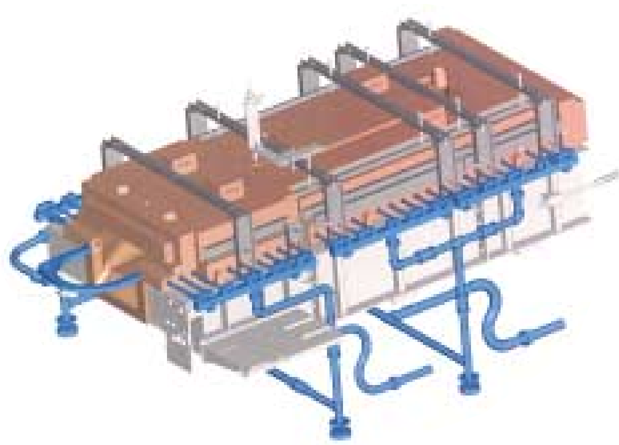
If this production consistency can be maintained, the furnace has performed its function and the responsibility for maintaining process integrity passes to the forehearth.

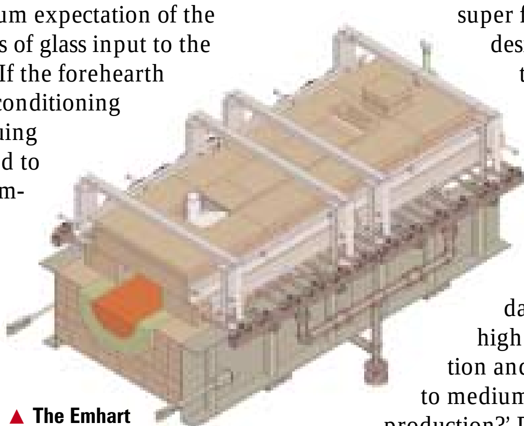
The process in terms of the furnace/forehearth interface is a critical one. Forehearths simply do not have the subsystems to rectify furnace faults. Consequently furnace derived problems will be fed by the forehearth to all subsequent stages in the manufacturing process, through the feeder mec
end inspection process.
performed as expected, the critical interface becomes that between the forehearth and the feeder mechanism, and ultimately



The Emhart Glass 540E Forehearth.

to the forming machine. The role of the forehearth in the forming process is becoming more critical as the demands of new forming techniques and processes evolve. The demands on early forehearth designs were as modest as the glass quality they delivered. Forehearth designs and their cooling and heating systems were crude and the lateral and vertical thermal homogeneity of the glass delivered to the spout was poor. Modern forming processes and ware quality expectations are significantly less tolerant of bad forehearth performance. The role of the forehearth in the forming process has been redefined and is encapsulated in the term conditioning.

Conditioning is a purely thermal process and can be defined as the achievement of a stable, desired glass temperature, distributed throughout the vertical and lateral planes of the glass at the entrance to the spout. This effectively defines the minimum expectation of the forehearth in terms of glass input to the forming machine. If the forehearth fails to achieve its conditioning objectives, the ensuing problems will be fed to the subsequent forming process.



▲ **The Emhart Glass 240 Forehearth.**

Quantifying the influence of poor forehearth performance on glass forming and on the final product is not without difficulties. The reasons for ware rejection are many.

Approximately 100 types of defect have been identified, around 50% of which may be related to the temperature and thermal homogeneity of the glass, and by implication to the effectiveness of the thermal conditioning properties of the forehearth design. It is difficult to be exact when discussing this area as many of the defects defining ware rejection can also be attributed to other aspects of the forming process. It is clear however, that in terms of forming problems and ware rejection, the role of the forehearth is significant. This defines the importance of the forehearth/forming machine interface and the vital role of the forehearth in the forming process.

An improvement in the rejection rate and the requirements for faster machine speed are inherently linked to thermal homogeneity levels and to thermal stability. However, it is not simply forehearth performance during stable operation that defines forehearth efficiency. The ability of the forehearth to achieve thermal stability rapidly after a job change is a key element in the efficiency of the overall forming process. The time required to stabilise the glass after a job change is a function of the response time of the forehearth, and is determined by the efficiency of both the combustion and cooling systems, as well as the effectiveness of the superstructure geometry. Forehearth efficiency and the conditioning process are also intricately linked with combining the correct forehearth design with the production requirements.

Advances in refractory and control technology have produced forehearths that are capable of operating over a wider range of operating conditions than ever before. The same period, however, has also witnessed the introduction of super forehearths designed to facilitate tonnages in excess of 220 tonnes/day. This provokes the inevitable question; 'How can one forehearth design accommodate the demands of high tonnage production and still be applicable to medium and low tonnage production?' Does this not imply that rather than one universal forehearth design, applicable to all production requirements, there is a need for a family of forehearth designs each designed specifically to reflect the different operational requirements of low, medium and super high tonnage production?

Emhart Glass believes that the forehearth design should reflect the production requirements of the forming process and that the industry expects better than the one fit solution currently offered.

The Emhart Glass 540 Forehearth has been a high tonnage workhorse for almost 20 years and through innovative refractory design and control configuration, it continues to be one of the most advanced and effective large tonnage conditioning systems available today. However, the production requirements of today's glassmakers are as diverse as the articles they produce. It is disingenuous to contend that the requirements associated with tableware production are identical to those encountered by high tonnage, triple gob container producers, or that the operational requirements of glass block producers are similar to those associated with TV screen production. Different problems and different requirements necessitate different solutions.

Emhart Glass has recently introduced a new forehearth system aimed specifically for the low tonnages (3-20 tonnes/day) that are common to small ware and tableware production. To fit into the company's family of forehearths, it has been named the 240 forehearth. Launched earlier this year, the 240 has attracted considerable interest and has been adopted by a number of glassmakers. The 540E forehearth system was also introduced earlier this year, and several systems have already been supplied to container ware producers. Derived from the Emhart Glass 540, it has, through the use of alternative PID control strategies and combustion configuration, been specifically designed to offer an effective conditioning solution using a less complex control and combustion implementation. The new Emhart Glass 340 will be introduced shortly to complete the family of forehearth systems. It has been in development for six months and is based on extensive mathematical modelling. The first experimental test rig was built in March 2002. Results of mathematical and physical modelling predict that it will produce unprecedented conditioning power and heat removal rates. The first fully operational 340 will be commissioned later this year.

It could be argued that no individual element of the forming process supersedes another in its influence on the overall process. All elements can produce unique problems that net the same result - rejected ware. The new family of Emhart Glass forehearths however is designed to ensure that whatever is happening in subsequent systems, the conditioning function of the forehearth will ensure its role is fulfilled. Hopefully the raw material supplier will sleep more soundly.

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