Good gob, bad gob

John McMinn* highlights the importance of the forehearth in gob formation and glass distribution within the container.

Thermal gradients within the gob and temperature differences between gobs produced from adjacent orifices are a significant factor in container faults and ware rejection.

It is crucial to have knowledge of the factors that determine good gobs and bad gobs and how to eliminate or mitigate the production of bad gobs.

The quality of the gob is essentially determined by the forehearth design, the skill level of the forehearth operator and the resultant achievable thermal homogeneity of the forehearth exit plane at the spout entrance.

Some years ago I was fortunate to work with Matt Hyre at a time when he pioneered mathematical modeling of the entire forming process. Among the models Matt produced was a study of the causes of thermal inhomogeneity in the gob produced by the operation of the forehearth.

Matt used numerical simulation to model the flow of glass through the forehearth and spout and its subsequent passage through the forming process and into the final container. This allowed a study of the influence of forehearth performance on container quality. The results of this study proved the old adage that a good bottle is made in the forehearth; or more precisely, consistent gob and container quality is dependent on control and consistency of the forehearth exit plane temperature profile.

Prior to the equalising zone the flow pattern of the glass within the forehearth is laminar. As the glass nears the spout entrance the flow is influenced by both the tube rotation, the downward flow of the glass and the plunger action. Within the spout the orientation of the orifices has a large influence on the glass flow pattern.

The glass delivered to the different orifices originates from different areas of the spout entrance plane. For example, if the forehearth is operating with straight line shearing, the glass entering the spout at the bottom right hand side exits mainly through the inner orifice whereas the glass entering the spout at the bottom left hand side hand exits mainly through the outer orifice. The glass in the bottom central area will exit mainly through the outer orifice. Since cord-rich glass will concentrate at the bottom central area this explains why it is common for one gob to contain greater quantities of cat scratch cord than the other gob.

Parison forming

Temperature gradients within the forehearth exit plane can produce an uneven temperature distribution in the spout that affects the temperature distribution within the plungers and the orifice ring. This results in gobs with different weights and temperatures. Due to the lower viscosity the hotter gob will be longer than the colder gob. The mould receiving the higher temperature gob will have a higher surface temperature than that receiving the colder gob. This has a negative impact on the forming of the parison since the hotter gob will produce a longer parison before invert due to the lower viscosity. As a consequence of this the region of the parison that will form the heel of the container will be thicker for the hotter gob. As a result of the differences in parison length the final blow will occur too early for the shorter parision resulting in a thinner bottom and a thicker neck. The differences in glass thickness distribution are significant, the smaller gob will produce a thinner heel and base, the larger gob will produce less thickness variations that will make the container less likely to fail under pressure.

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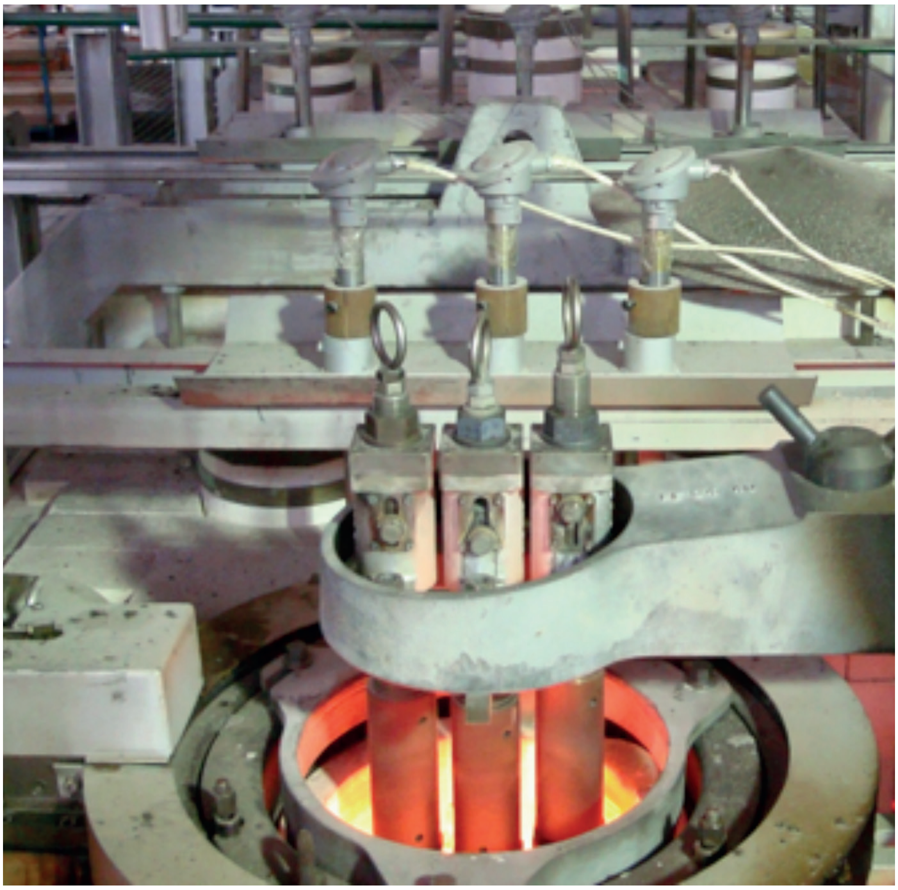

As discussed above different areas of the forehearth exit plane exhibit preferential flow patterns dependent on orifice orientation but thermal gradients at the spout entrance also produce thermal gradients in the gob irrespective of orifice orientation. It is common practice to define the exit plane with a nine-thermocouple point grid defining the exit plane into three horizontal levels and three vertical columns. However studies have found that not all nine points are of equal importance in the formation of the gob. The area defined by the three vertical central thermocouples and the bottom RHS and LHS have much more influence than the areas defined by the top RHS and LHS thermocouples. Forehearth operation should concentrate therefore on achieving minimal temperature gradients between the central vertical column and the side bottom glass streams.

Forehearth control strategies, such as cascade and bias control, that aim to control the forehearth exit plane temperature profile, have been available for many years, but individual zone set-point manipulation remains the most widely used means of controlling the glass temperature profile at the spout entrance. The effectiveness of this is determined firstly by the expertise and experience of the operator but crucially by the reaction of the forehearth to the changes in operational parameters.

Forehearth Services specialises in determining what factors prevent the forehearth from achieving a thermally consistent forehearth exit plane.

Performance audits

Now in its 10th year Forehearth Services has conducted forehearth performance audits around the world on all major forehearth designs (and several, shall we say, less conventional designs). This has allowed us to acquire a unique insight into the efficacy of the various designs and the level of performance achieved by the users in various glass plants.

Within the container and tableware sectors of the industry there exists a wide discrepancy between the theoretical performance of the forehearths and the actual operational performance. This observation is based on Forehearth Services' forehearth performance audits that have consistently identified large variations in both design efficacy and performance. Surprisingly, and disturbingly, not one single forehearth audited within the past 10 years was found to be operating correctly with the result that the consistency of the forehearth exit plane temperature profile was compromised – and as a result production and container quality were correspondingly affected.

There are many reasons why a forehearth fails to deliver the theoretical performance level but operator skill levels and inappropriate maintenance schedules are often to blame. Often poor forehearth performance is due to combinational elements that not only compromise the forehearth exit plane thermal profile but manifest in slow response and excessive fuel consumption.

Using analytical techniques developed by Forehearth Services it is possible to identify and rectify all factors that prevent optimal forehearth performance and compromise the forehearth exit plane thermal profile. ■

*Managing Director, Forehearth Services, UK
Email enquiries@forehearthservices.co.uk.